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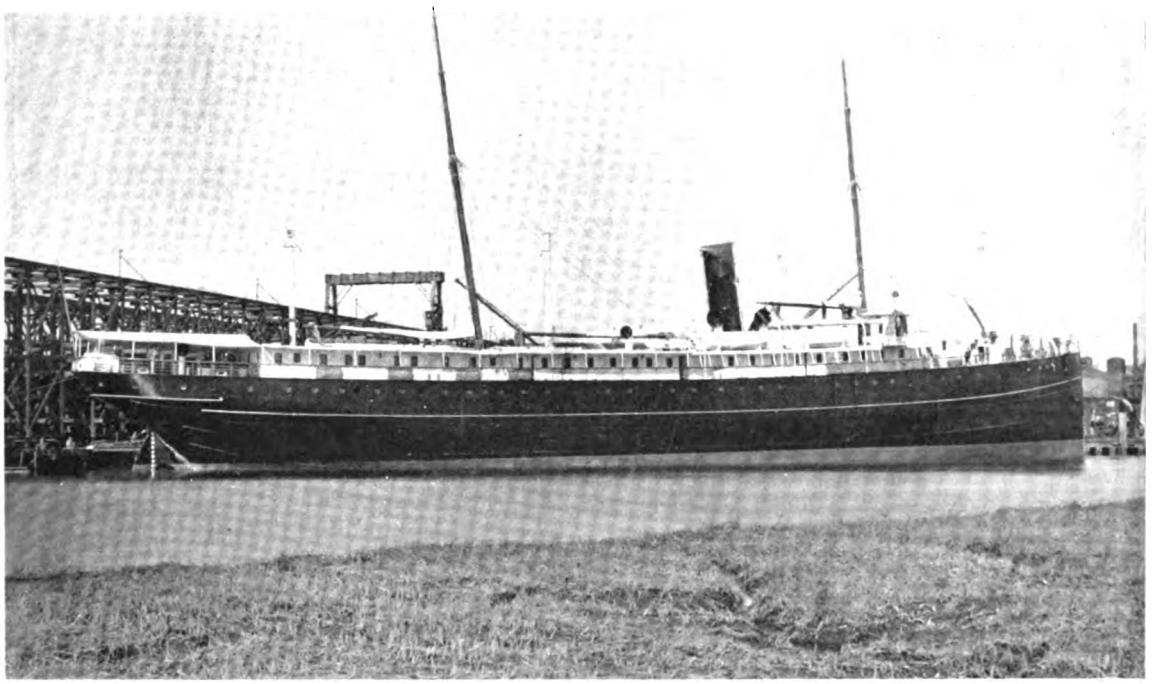
STEAMSHIP JUNIATA FOR THE MERCHANTS AND MINERS TRANSPORTATION CO.

The latest addition to the fleet of the Merchants and Miners Transportation Co., the steamship Juniata, is here shown. She was launched recently from the yards of the Harlan & Hollingsworth Co., at Wilmington, Del., and is the fourth vessel built at this yard for the line. The Juniata is a four-deck steamer, 270 ft. long on the water line, 42 ft. moulded beam, and 34 ft. deep. She is fitted with two-pole masts and one funnel, and in design is an unusually handsome boat, not unlike a transatlantic liner. The passenger accommodation is fully in keeping.



MERCHANTS AND MINERS TRANSPORTATION CO'S STEAMSHIP JUNIATA.

On the main deck, the dining saloon is 80 ft. long and 22 ft. wide, with seventeen communicating state rooms. It is fitted with six separate tables, which can be joined together so as to make two long dining tables, and is finished in white and gold. A wide staircase leads up to the social hall, which is covered by a handsome dome fitted with a large ornamental electric light cluster. The social hall is also finished in white and gold, and opening on this are forty state rooms; the open well in the center of the hall lights up the saloon below. Wide berths of modern design are fitted in the state rooms, and the toilet conveniences are of artistically enameled ironware. Accommodations for the second-class passengers are fitted forward on the main deck. Quarters for the crew have been carefully planned for comfort and convenience. The officers are berthed on the upper deck, their quarters communicating with the pilot house, so that they can go to and fro in bad weather without being exposed. Aft of the midship house on this deck the officers' dining room is situated above the

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galley, which is connected by a dumbwaiter. The room is finished in sycamore and the floor laid in ash. The engineers' rooms are finished in hardwoods and fitted with the usual speaking tubes and accessories. On this deck there is also a smoking room for passengers, finished in sycamore, with cherry and maple wood tile floor. Aft of this room there is a toilet room for men, with marble furnishings and tile floor. From the pilot house on the boat deck a flying bridge extends to the sides. The pilot house is finished in butternut, the ceiling being colored blue and the floor and grating of polished ash. Power steering wheel and the usual binnacle and telegraph apparatus is fitted, as well as a chart case and flag locker. The captain's room, just aft, contains a folding bed, with a roll top desk, wardrobes, and large book case with French plate mirror panels. A private toilet room connects with the captain's room. A powerful searchlight is in position over the pilot house.

The machinery equipment of the Juniata is quite modern. The engines are of the inverted triple expansion type, with cylinders 28 in., 45 in., and 72 in. dia., and 48 in. stroke. The propeller is 16 ft. dia., 23 ft. pitch, and is made of Manganese bronze. There are four Scotch boilers, 13 ft. 6 in. dia., and 11 ft. 6 in. long, built for a working pressure of 160 lbs. per sq. in. The electric lighting sets are in duplicate furnishing current for lighting the ship with incandescent lamps throughout, and also for the searchlight, and for a system of ventilating fans. On a draft of about 18 ft. of water a sea speed of 15 knots is obtained.

While this issue is in the press the New York meeting of the American Society of Mechanical Engineers will have been opened, at the headquarters, 12 West Thirty-first street, New York, by President Worcester R. Warner. The programme for the technical and social features of the meeting, issued in the form of a little booklet, shows that excellent care has been taken to make the meeting a most enjoyable and profitable reunion. The opening session is set for November 30, when at 9 o'clock in the evening President Warner delivers an address on "The Evolution of the Telescope." Before this hour, however, the rooms are to be opened for the reception of members. Other equally pleasant social occasions are provided, and include invitations to members and guests to luncheon on Wednesday and Thursday, and on Wednesday evening to a reception and conversazione at Sherry's, to which ladies are especially invited. The list of technical papers shows also that Secretary F. R. Hutton has been very successful in adding important papers to the transactions. The papers read at the meeting of special interest to marine engineers are those by Andrew Fletcher, upon "The Stevens Valve Gear for Marine Engines," and George W. Dickie, on "Auxiliary Engines and Transmission of Power on Naval Vessels."

ON THE INFLUENCE OF SURFACE ON THE PERFORMANCE OF SCREW PROPELLERS.*

Preliminary Paper.

BY PROF. W. F. DURAND, MEMBER OF COUNCIL.

The performance of a screw propeller involves fundamentally the following features: The work absorbed, the thrust developed, and the useful work returned, together with the ratio of the last to the first as expressing the efficiency of the transformation of which the propeller is the immediate agent. This performance, in turn, depends on the following chief items: (1) The dimensions of the propeller. (2) The conditions of its use. The former includes diameter, pitch, and area or surface. The latter includes revolutions and speed of advance, and slip as resulting from them.

Pitch may be uniform or variable, and if the latter, the variation may be axial or radial, or both, in any degree or with any distribution, no matter how complex.

Area includes two specifications: (1) Amount and (2) Distribution, or shape and number of blades.

The performance depends also on a variety of minor variables, such as: Thickness of blade and its distribution, or the form of the cross-sections of the blade; the material of the blade; the general shape of the blades as resulting from variations in the mode of generation, such as blades bent or curved back from the plane of rotation, blades bent or curved in the plane of rotation, etc. The effects of these variables we shall at present disregard.

The performance of a propeller is also fundamentally dependent on the ship in connection with which it works, or, to state the relation more exactly, the characteristics of the ship will, to a greater or less extent, affect the conditions under which the propeller works, and thus affect the performance through them.

The investigation of propeller performance thus naturally divides itself into two fundamental parts: (1) The performance of the propeller in still or undisturbed water. (2) The modifications due to the interactions between the ship and the propeller in the actual case. In the present paper we are concerned wholly with the first subdivision, the performance of propellers in still or undisturbed water.

The most extended and undoubtedly the most reliable experiments on propellers of which we have the data were those made by R. E. Froude, and reported on in 1886.[1] In these experiments, diameter, speed of advance, and area, both in amount and distribution or shape, were kept constant; the former at .68 ft. and the latter at a disk

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*Paper read before the Society of Naval Architects, Marine Engineers, New York, November, 1897.

[1] Transactions Institution of Naval Architects, London, Vol. XXVII, p. 250.

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area ratio of about .36, with propellers having four elliptical blades with maximum width .4 the radius. The investigation then covered the ground involved in the variation of the other features as noted above, viz., pitch or pitch ratio, and slip or revolutions. The investigation of the influence due to gradual variation in the area was not one of the fundamental purposes of these experiments, and the information relating to this point was restricted to the results arising from a reduction in the number of blades from 4 to 3 or 2, their shape and size remaining the same throughout.

In the experiments to be hereafter described, an additional variable element—that of the amount of area—is to be introduced. In these experiments, therefore, diameter, speed of advance, and shape of blade as well as number of blades are kept constant; while amount of blade area, pitch or pitch ratio and revolutions or slip are subject to variation. The essential feature of the present investigation is therefore the relation of the amount of area to the performance as a whole. There seems to be reason for believing that the influence due to change of area includes that due to change in number of blades, or, in other words, that with given area and usual proportions the performance is but slightly dependent on the number of blades. This may require further examination at a later point, but in the meantime no serious error will be made by accepting the above proposition as substantially correct.

We shall not here enter into any detailed discussion of the utility or propriety of model experiments. In the last twenty years experiments of this character have steadily advanced in scientific standing, and have won for themselves a secure place in the development of our present knowledge of ship resistance and propulsion. It will be sufficient to note that in the case of propellers of constant area ratio, shape and number of blades, slip and pitch ratio, the assumption is made that the work involved in the performance may be considered as varying directly with the square of the dimensions and with the cube of the speed. This relation may be expressed in a variety of forms, one of the most useful of which is as follows:

$$U = d^2\,(pn)^3\,(aihk),$$

where U = useful work;
d = diameter;
p = pitch;
n = revolutions;
$(aihk)$ = conjointly a coefficient or factor in which—
a = area factor;
i = shape factor;
h = pitch ratio factor;
k = slip factor combined with the necessary factor to provide for the units of measurement used.

These factors are, of course, interdependent, and the chief purpose of writing the equation in this way is to emphasize the leading features upon which the performance as a whole must depend. The experiments of Mr. Froude furnished data from which values of the factors h and k may be derived for one given value of the area, and one given shape as employed. The present experiments are intended to furnish data from which values of the factors a, h and k may be derived for the constant elliptical shape of blade employed.

The problem immediately before us is, therefore, the experimental determination of the data necessary to this end. As already seen, there are three modes of variation—pitch ratio, area ratio, and slip. Of these, the first two belong to the propeller, and the third to the conditions of use. To cover the ground satisfactorily, there will presumably be required from four to six or more determinations for each mode of variation. Thus six or seven pitch ratios, each with five or six area ratios, making about forty propellers, each tried at five or six values of the slip.

Of this work, only that relating to one pitch ratio has as yet been accomplished, and the present paper is written for the purpose of placing before the members of the society a brief description of the experiments as projected and thus far carried out, with a preliminary statement of the results obtained. The completion of the entire series will necessarily require some time, and it is thought that even should the results in their complete form give rise to some modification of the values thus far derived, yet the general trend of these values will not be far from correct, and their interesting and suggestive character may be a sufficient excuse for their presentation without further delay.

Apparatus and Matériel.

The experiments here reported were made on propellers of the following dimensions:

Reference No.	Diameter.	Pitch.	Area ratio.	Max. width of blade ÷ radius.	No. of blades.
2	1'	1'.3	.18	.2	4
3	"	"	.27	.3	"
4	"	"	.36	.4	"
5	"	"	.45	.5	"
6	"	"	.54	.6	"
7	"	"	.63	.7	"
8	"	"	.72	.8	"

The number of the propeller and its pitch ratio serve to identify it, the number corresponding to maximum width ratio and to area ratio, as seen by comparing the first, fourth and fifth columns.

The elements directly to be measured in any given experiment on one of the propellers are as follows: (1) The power absorbed. (2) The thrust developed. (3) The revolutions. (4) The speed of advance in undisturbed water.

The facilities of an experimental tank not being available, it was decided to mount the necessary apparatus on the bow of a small steamboat, the propeller to be tested projecting forward into undisturbed water, and the boat serving as a carriage whereby any desired speed of advance may be obtained.

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Arrangement of Propeller Shaft and Fittings.

The arrangement of the propeller and shaft is shown in Figs. 1 and 4. AB is a pipe surrounding the shaft proper, and provided at its forward end with a ball-bearing, shown in detail in Fig. 4. This pipe, at the rear end, passes through the stem of the auxiliary box or false bow, as shown, and is connected with a watertight joint to the forward end of the thrust dynamometer *C*. The water has free entrance to the pipe through the forward ball-bearing, and as far aft as the forward end of the dynamometer *C*. The shaft proper is coupled to the brass plunger-rod of the dynamometer, as shown in Fig. 4, and the fit between this rod and the dynamometer end is so perfect that no water can leak through. Under the conditions of use, in fact, the pressure is greater in the dynamometer than without, and the only leakage would necessarily be from within outward. The pipe is supported at the forward end by iron bands depending from the framework attached to the bow of the boat.

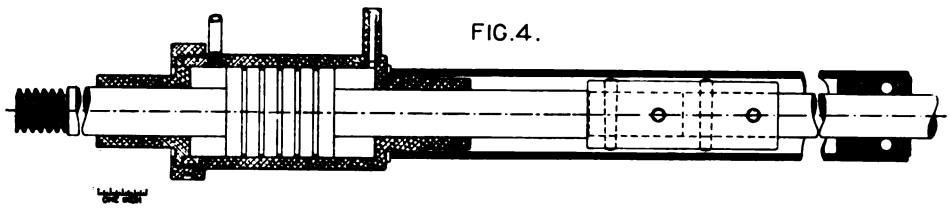

FIG. 4.

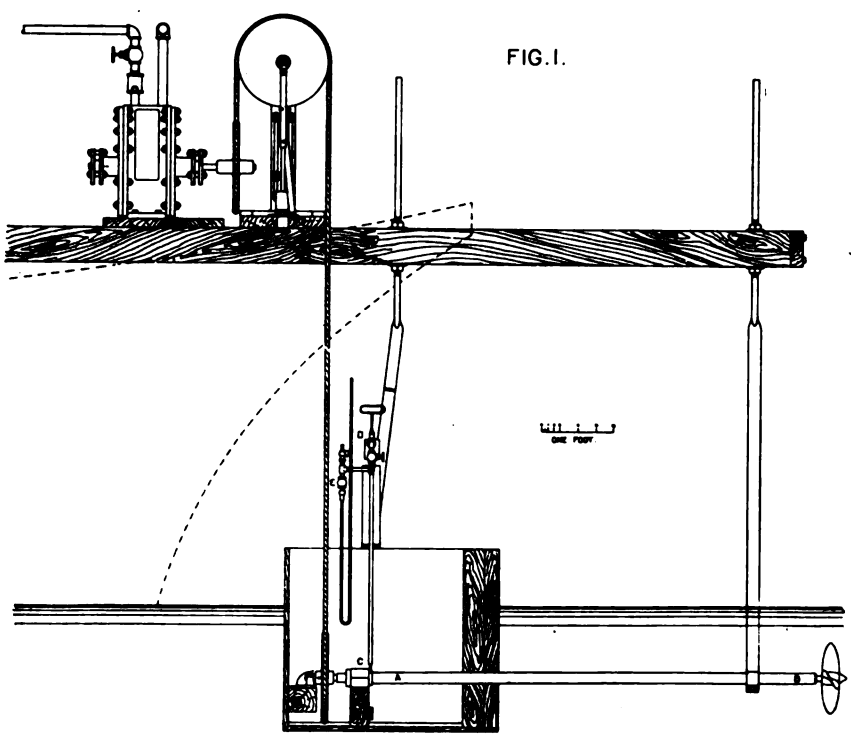

FIG. 1.

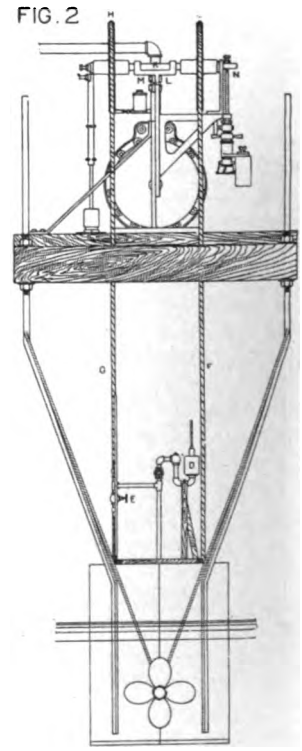

FIG. 2

These rods are very thin in transverse dimension, and are drawn down to sharp edges fore and aft so as to give rise to the minimum disturbance in passing through the water.

Thrust Dynamometer.

This dynamometer consists of a plunger and oil cylinder, as shown in Fig. 4. They are accurately fitted by grinding and lapping, with a difference of somewhat less than .001" in diameter. This difference is sufficient to insure perfect freedom of movement, and the presence of a definite layer of oil between the plunger and the walls of the cylinder. The plunger and rod are in one piece, and the forward end of the latter is coupled to the shaft as noted above. The after end projects to the rear and carries the driving sheave, and is also fitted with a screw for attaching a counting device. This rod passes through a solid bearing at each end of the cylinder, and is fitted by grinding and lapping, as with the plunger. In the forward end of the cylinder is a pipe leading to the mercury gauge for measuring the pressure. In the after end is an opening giving free escape for such oil as may leak past the plunger. As indicated above, a small leakage was desired in order to insure complete lubrication of all moving parts, and in use the cylinder thus becomes filled with oil on both sides of the plunger, the slight amount lost being made up by a pump connected with a pressure gauge.

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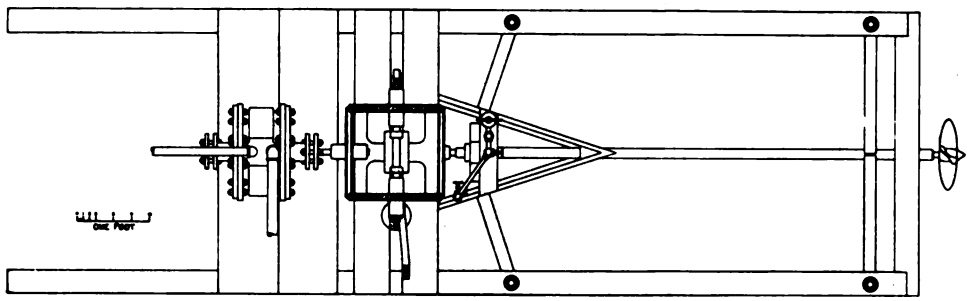
The propellers are run at a number of revolutions somewhat greater than would correspond to the speed of the boat, thus giving a sternward acceleration to the water acted on, and a forward reaction. This gives rise to a pull on the shaft, and the oil on the forward side of the plunger then furnishes a ready means for the transmission of the pressure to the mercury column, where it is measured. The fundamentally important point of the dynamometer is, that when the plunger is revolving, all longitudinal friction is eliminated, and the delicacy for the measure of the forces involved becomes very great. The cylinder is bedded in a cast-iron seat attached to the bottom of the box, and the latter is securely stayed longitudinally to the boat, thus securing the necessary longitudinal rigidity.

The measurement of the pressure is by means of an open mercury manometer, as shown in Fig. 1. The hand-pump *D* for making up the loss due to leakage has been already referred to.

FIG. 3.



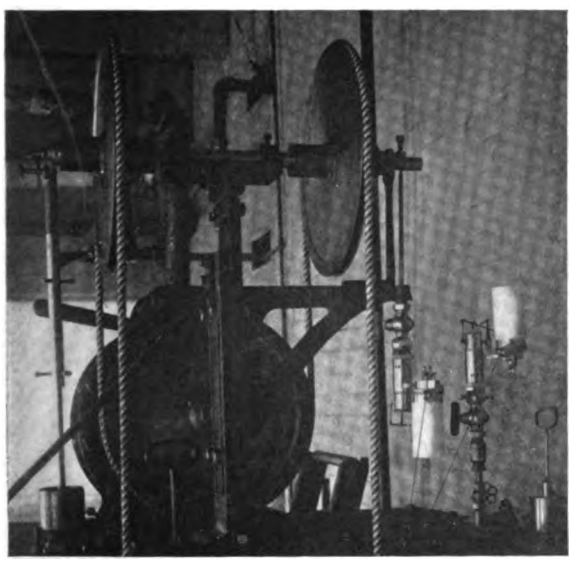


FIG. 5.

No trouble whatever was experienced in running the course of 1,000 ft., or longer if desired, without replenishing the oil. The stop valve *E* is for the purpose of damping any tendency in the column toward vibration due to periodic fluctuations in the pressure measured. If the valve is wide open, the column shows with great delicacy the fluctuating values of the pressure; but, for purposes of registration, a more accurate mean value may be determined by choking down the fluctuations to a small range. Actually this may be accomplished with great nicety, and in no case, under usual conditions, was the momentary fluctuation more than a small fraction of the total quantity measured. The performance of the thrust dynamometer and pressure manometer was exceedingly satisfactory, and, I believe, leaves little to be desired as to delicacy, accuracy, steadiness, readiness of calibration, and general reliability. The manometer as used in these experiments was not self-registering, but was read by an observer at intervals of a few seconds throughout the run. This gave a very satisfactory value for the mean, but required, of course, the services of an extra observer.

Transmission Dynamometer.

For the transmission dynamometer the arrangement shown in Figs. 1, 2, and 5 was used, constituting a special form of rope dynamometer. The ropes *F* and *G* lead from the driving sheave on the after end of the propeller shaft, the former being the tight and the latter the loose side.

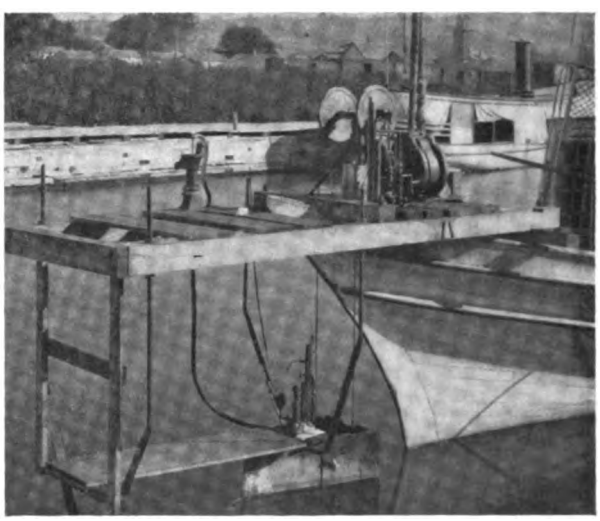


FIG. 6.

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These pass over sheaves H and I and then around the sheave on the motor shaft. These sheaves are all of the same diameter, in the present case 15 in. The sheaves H and I are mounted with ball-bearings on a shaft K, which is carried by a block $L\,M$, the latter being connected to the base by a pair of thin steel plates or springs. This is the well-known Emery support or substitute for a knife edge, and for slight movements is almost perfectly frictionless, at the same time affording rigidity in the directions desired.

The sheaves H and I and their shaft thus form a balanced rocking system or lever pivoted in the middle, and therefore without deflection, so long as the tension on the two sides of the rope is the same. When running, however, the difference between the tensions on the tight and loose sides will determine a moment which will tend to throw this arm down. This motion is prevented by a strut connected with the arm N by a spherical joint, and resting on the bottom of an inverted steam-engine indicator piston. The compression of the indicator spring is then used to measure the moment, and thence, knowing the revolutions, the power transmitted is immediately known. The indicator drum was given continuous and uniform motion in one direction only, by connecting it through a cord with the main drum of the Weaver recorder. The chief points of this dynamometer are the ball-bearings and Emery support, and their influence in reducing friction to a minimum is of great value in reducing the perturbing influences which may affect the operation of the instrument. In order to provide the same relative delicacy of reading for both thrust and work absorbed, a new form of oil-cylinder, mercury-column measuring device for the transmission dynamometer has been designed and built, and will presumably be used in the remainder of the experiments.

Motor.

For driving the propellers a small rotary engine was used as indicated in the figures. This gave a nearly uniform turning moment and proved itself very satisfactory for the purpose in view.

Records of Revolutions, Time, and Distance.

All records relating to revolutions, time, and speed were recorded on a Weaver time and speed recorder, which, it will be remembered, consists essentially of a modified Morse register with a number of pens under electrical control.

The Course.

For the course a distance of 1,000 feet was measured off on a railroad tangent running close to the east shore of Cayuga Lake, where the beach is bluff and deep water extends close to the shore. This distance was divided into ten parts of 100 feet each, and by a surveyor's transit, lines at right angles to the course were determined and marked by ranges, the front row near the water's edge, and the back row some distance in the rear. The conformation of the shore was such that, by going a little to the north of the course, it became possible to lay off by range marks on the distant hills a parallel course through deep water about 200 feet from the shore. The course to be followed became thus definitely determined in direction, location, and extent. A similar course was also laid off on a straight reach of the "Inlet," a channel about 100 feet wide leading from the lake to the city. Most of the work was done on the outer course, the "Inlet" course being used only when the water on the lake was too rough for regular work outside. The observations re-

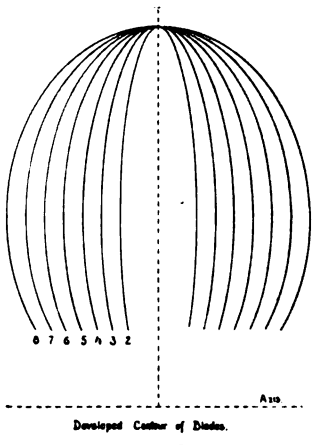

FIG. 8.

lating to the ranges were made by an observer holding a circuit-breaker in his hand, which was closed opposite each range, thus furnishing ten series of distances of 100 feet each. This sub-

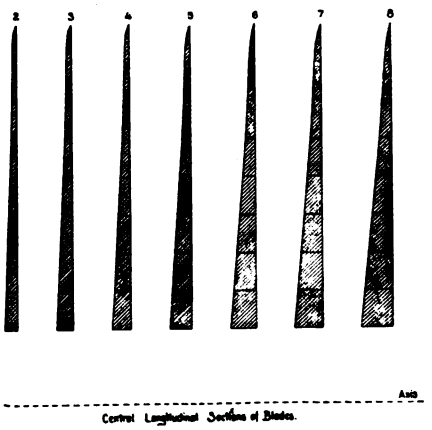

FIG. 9.

division of the entire course was found advantageous for many reasons. If, due to disturbing influences, the conditions of speed or revolutions were not quite regular during any part of the run, or if, due to other causes, the data from a part of the run might be questioned, such part could be eliminated, and there would still remain a distance of several hundred feet over which the conditions were constant within the requirements of the work. In general, however, the conditions

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were substantially constant throughout, and the data taken related, with few exceptions, to the entire distance of 1,000 feet.

The Clock.

A clock with second's break specially arranged for this work furnished a signal each second, thus giving, in conjunction with the range signals, the speed per minute or per second.

The Revolutions.

By a reducing gear, every tenth revolution of the propeller was recorded on the tape, the marks being at such distances that, by interpolation, the

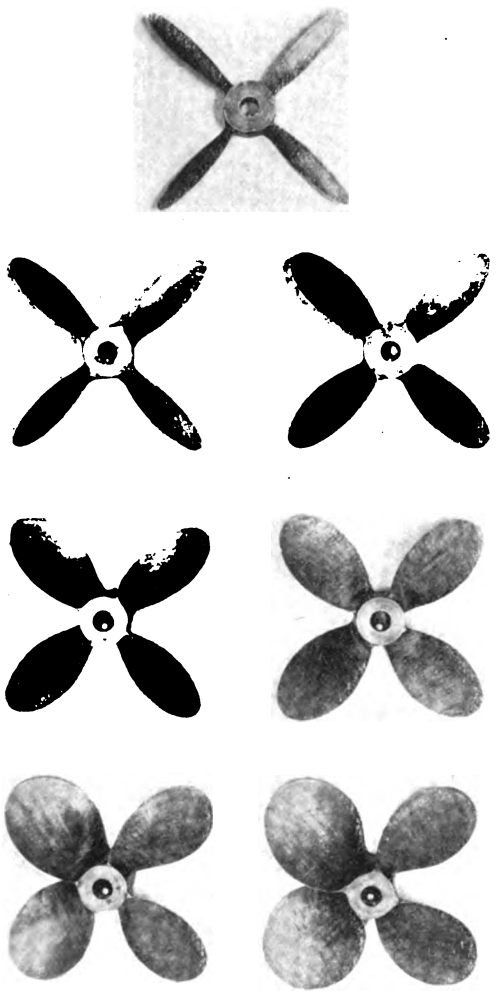

FIG. 7.

revolutions to a single unit could readily be determined. This furnished the data for the determination of the revolutions per minute or per 100 ft. or per 1,000 ft., and thence, knowing the pitch, for the determination of the slip. The revolutions of the motor direct were indicated by a tachometer, which was merely used as an indication, and not as a measure. By the aid of this indication, the person in charge was able to control the speed of the motor sensibly constant at any desired point.

Speed of Boat.

The speed of the boat through the water was controlled by the revolutions of the main engine, and also by a weighted rod or pendulum hung over the side and pivoted so that the motion of the boat would cause it to tend aft. A pointer extending from the axis upward swept over an arc, and thus furnished a sensitive indication of variation in the speed through the water. This was, of course, an indication and not a measure, but was quite sufficient to enable the engineer to note instantly the condition of the boat relative to the desired speed. The actual speed itself was taken as the mean of four runs north and south over the course, measured as described above.

The Propellers.

These are shown in Figs. 7, 8, and 9. They are of brass, four-bladed as shown, and the blades are of elliptical contour when developed, with maximum widths as shown by the table above. For making the propellers a wooden pattern was

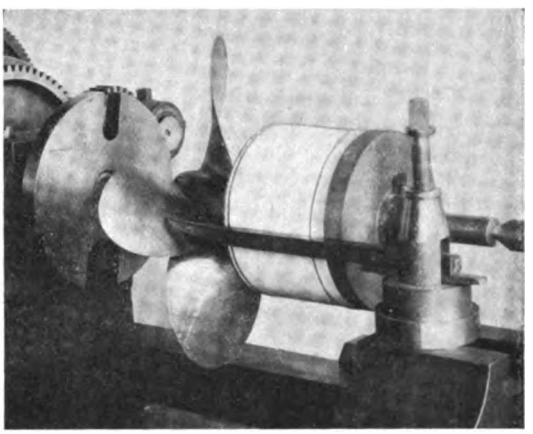

FIG. 10.

first prepared for No. 8. This propeller being cast, the pattern was reduced in blade width and thickness, and No. 7 was next cast, and so on down to No. 2, but one original pattern being thus required for the entire series. For the measurement of the pitch thus resulting, the device shown in Fig. 10 was used. The propeller in hand was bored, fitted on a mandrel, and swung in a lathe face outward. Fitted on the same mandrel was a drum of diameter, say, .7 that of the propeller. On this drum was secured a strip of paper. A square steel bar was then fitted in the tool post with one edge parallel to the lathe axis. At the end next the propeller the bar was drawn down to a point lying in the upper and inner edge of the bar. Farther back, and opposite the drum, a nick was made in the same edge. Now, it is obvious that if the bar be run in till the edge above referred to is just clear of the drum surface, and if the carriage be so moved longitudinally that the point of the bar rests constantly on

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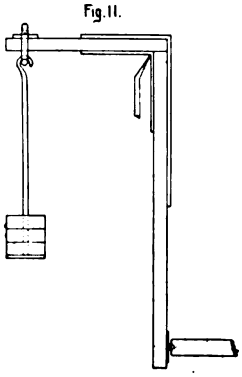
the surface, then all points on the bar will trace, relative to the drum, like helices, and hence like that traced by the end of the bar on the driving face of the propeller. A pencil held in the nick of the bar will therefore describe on the paper a copy of the helix on the propeller, and will therefore serve to determine the pitch across the blade at this radius. Four such drums were used at radii .3, .5, .7, and .9 the outer radius, the hub radius being .2 the outer radius. In this way a sufficiently complete knowledge of the history of the variation of pitch over the driving face could be determined. Conversely the same apparatus was used to guide the dressing of the propeller down to the desired degree of constancy as to pitch. To this end a line was laid off on the paper making an angle a with the transverse determined by the equation:—

Fig. 11.



$$\tan a = \frac{p}{2\pi r},$$

where p is the pitch desired and r the given radius. By comparing the path of the nick as given by the actual surface with that which should be given, the points which are too high may be easily determined. At such points a little hollow was chipped out of a depth sufficient to bring the nick onto the line. A series of such spots being chipped out across the blade, it is evident that the bottoms of such points are on the surface desired. This being repeated on the other radii, similar series of points were determined. The whole surface was then reduced by grinding and filing until the bottoms of the holes were barely removed. The driving face was then taken as a sufficiently close approximation to the form desired. As described later, however, a further measurement at the completion of the experiment gave the data for an additional correction. The blade was then trimmed to the desired contour, the original casting having been made purposely a little larger in all dimensions. Next the back was reduced until the lay-out of the thickness was that called for by the drawings, and the propeller was ready for use.

Mode of Conducting an Experiment.

For the determination of a single point or item of the final data, two single runs were made, one north and one south. The current was very slight; indeed, many times not appreciable, and at other times, due to a surface set of the water caused by winds, it amounted to a few per cent of the speed of the boat. In any event, it was assumed that the mode of operation followed was the best under the circumstances, and such as to eliminate all sensible disturbance due to current or set in the water.

The boat being brought on the course some distance from the first range mark, the motor was started, and the revolutions were brought by tachometer to the desired point. The speed of the boat at the same time was brought to the constant value, and as the boat neared the range marks the counting and recording mechanism was thrown into operation. The indications of the mercury column on the thrust dynamometer were read and recorded at intervals of a few seconds while on the course. The fluctuations were in all cases slow and gentle, and usually from ten to fifteen readings were sufficient to give a closely accurate average of the indications. In the meantime the range observer closed his circuit on passing each range, and the other records were automatically recorded.

The data thus taken consisted of the following: (1) An indicator card from the power dynamometer. (2) A column of readings from the thrust dynamometer. (3) A strip of paper with dots giving time revolution and range marks.

Calibration.

For the purpose of standardization, the apparatus was erected in the laboratory and operated as nearly as possible under the conditions of use. The power dynamometer was standardized by means of a Prony brake applied on a wheel located on the end of the shaft, instead of the propeller. The thrust dynamometer was standardized by applying known thrusts by means of a right angle triangle having a knife-edge bearing, as shown in Fig. 11. The calibrations were made at various speeds, and a large amount of data was taken as the basis of these important determinations. The calibration of the power dynamometer was also determined by measurements and the known theory of its action. The difference would indicate the loss due to friction in the transmission apparatus. As might be expected, this was exceedingly small, and the values given by both methods of calibration seemed mutually consistent. In a similar manner the calibration of the thrust dynamometer was determined from the known area of piston, effective height of column, and specific gravity of mercury. This likewise agreed very closely with the experimental calibration, and indicated only a negligible amount of friction in the apparatus.

Reduction of Observations.

The data obtained as previously described was reduced as follows: The mean ordinate of the indicator card was determined, and from the calibration data the corresponding power was immediately known. Similarly the mean altitude of the mercury column was determined, and by the calibration data the corresponding thrusts were found. The revolutions per minute and per 100 feet for the entire course, as well as the speed per minute, were then determined by counting from the strip of tape. The two sets of results north and south corresponding to a given determination were then averaged and the results thus

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found were accepted as a series of values of speed revolutions, thrust and power, mutually corresponding the one to the others. This constituted the original reduced data. Naturally in such case the average speeds of the boat would not be exactly the same for all determinations, especially on different days and for different propellers; neither would the sets of revolutions be exactly the same under the dissimilar conditions mentioned. It became necessary, therefore, in order to put the data into form for plotting or investigation, to reduce it to constancy for some one feature. The data was first reduced to constancy of speed, the slip in each case being unchanged. A speed of 100 ft. per minute was chosen for convenience, the actual speeds having been about 270 ft. per minute. The reduction was made by assuming that, slip being constant in any case, all forces relating to the propellers vary at the square of the speed.

A correction was also introduced at this point to allow for such slight departures from the standard pitch ratio of 1.3 as existed in the propellers as actually used. To this end the propellers were again, at the conclusion of the experiments, measured for pitch in detail, as previously explained, and for each one a resultant mean pitch was derived in the following manner: The pitch on each blade at each of the four radial distances corresponding to the drums used in the measurement, and approximately at .3, .5, .7, and .9 the outer radius, was given a weight represented by the product of the width of blade at that point by the square of the corresponding radius. The mean of these was then found by the usual method for a weighted mean. In other words, a weighted mean was used in which the weight was proportional to the moment of inertia of the element of the propeller at the given radial distances, and therefore, as nearly as may be, to the thrust developed at each point, or by each element. The results thus found naturally varied sligthly from the desired value of 1'.3 or 15".6. All forces in the determined value were therefore so corrected as to reduce them to corresponding values for a pitch of 15".6, and therefore for a pitch ratio of 1.3 exactly. These corrections were made by taking the results of R. E. Froude for the relation for given diameter between thrust and pitch at given slip. This relation[2] is expressed approximately by the proposition that for constant slip the thrust varies as the reciprocal of the pitch ratio less the constant .17. Or, if c denote the pitch ratio, then:

$$T \text{ varies as } \left[\frac{1}{c} - .17\right].$$

Using this relation, all thrusts were reduced to the desired pitch ratio, it being assumed that for the very small change in pitch the rule might be extended to all values of the area. It was further assumed that the changes were too slight to sensibly affect the efficiency, and the values of the work absorbed were therefore corrected on the assumption of constant efficiency for the slight change of pitch involved.. In all cases the changes thus made were small and perhaps negligible, but inasmuch as there existed a reasonable method for determining the corrections, it seemed well to make them, even if in most cases they were hardly appreciable in amount. The results of these reductions are shown by the spots plotted in Figs. 12-16.

The data was next reduced to constancy of revolution, the slip in each case remaining the same. Revolutions of 100 per minute were also chosen for convenience, the actual number having been from 200 to 450. This reduction was also made by assuming that for constant slip all forces related to the propellers vary as the square of the revolutions. The results of these reductions are shown in Figs. 19 and 20.

In Figs. 12-16 the curves drawn through and among the spots are not, in all cases, those which would approximate most closely to them, but are such as seemed best to agree with the entire set of observations using the indications furnished by the cross curves in Figs. 21 and 22, and also, as noted below, taking provisionally the lines of Figs. 19 and 20 as rectilinear. The approximation to the actual spots is, however, in general quite satisfactory, and the curves thus drawn are then taken as the data from which the remaining diagrams are reduced.

For the reduction to constant revolutions, the results for each case gave very nearly a straight line. In consequence it was assumed, as referred to above, that such a line might be taken as representing the observations quite as well as any other curve drawn through or among the points. This was done, therefore, for convenience, and without assuming that the loci shown in Figs. 19 and 20 are naturally or necessarily rectilinear in character.

In Fig. 21 are shown curves giving the relation between thrust and area at constant slip, and in Fig. 22, similarly, curves showing the relation between work absorbed and area at constant slip.

The thrust multiplied by the speed gives the useful work, and this divided by the work required will give the efficiency. This will obviously be the same, whether derived from the data before or after reduction to constancy of speed or revolutions. In Fig. 23 are shown the curves of efficiency, collected together and plotted on slip. In Fig. 24 are shown cross curves from Fig. 23 giving the relation between efficiency and area at constant slip. All curves following Figs. 12-16 are derived from the lines of these diagrams, and not from the spots, and hence represent the data in this reduced condition.

The detailed work of the reduction of the observations was performed independently by two assistants, Messrs. Preston and Norton, of Cor-

[2] Transactions Institution of Naval Architects, London, Vol. XXVII, p. 250.

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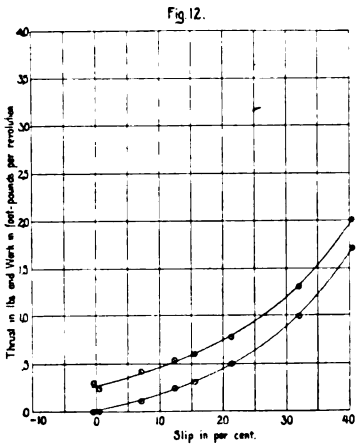
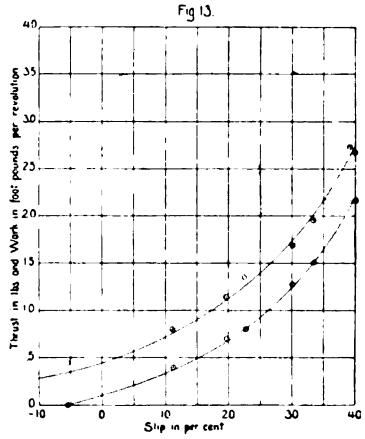
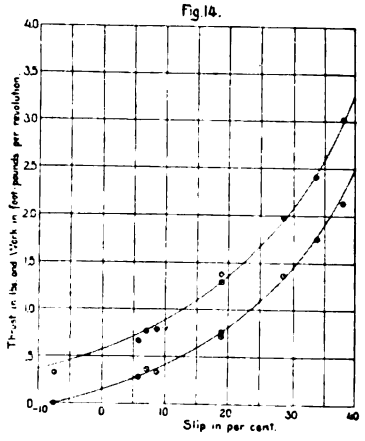
nell University, and, in part, by the writer, and is believed to be numerically correct.

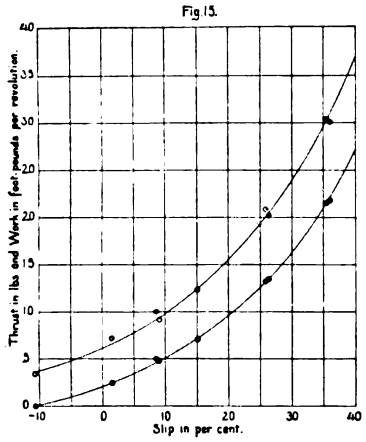
Discussion of Results.

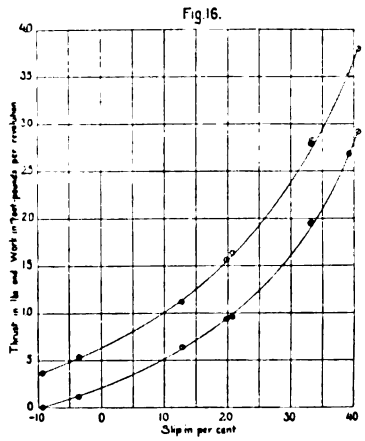
In Figs. 12-20 it will be observed that the limits of slip have been pushed beyond those

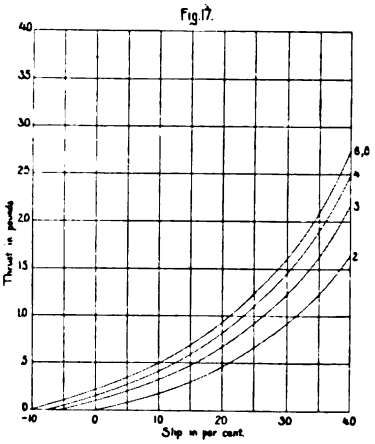


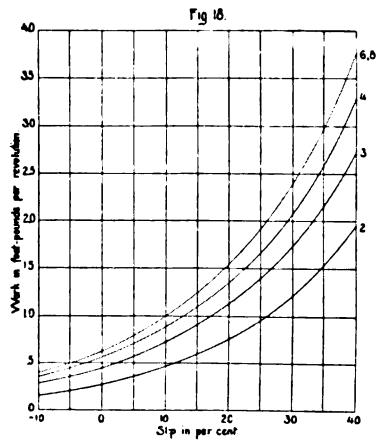


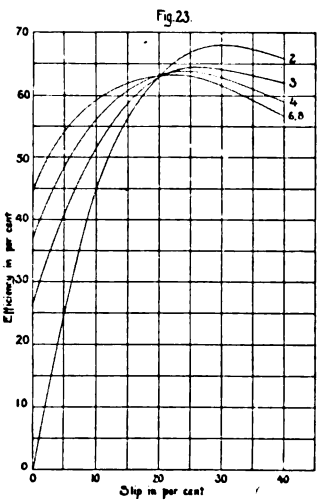


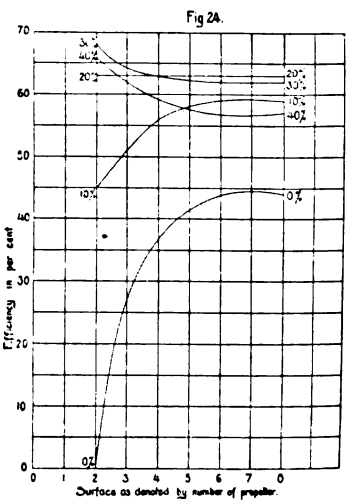












actually employed, especially on the lower side. In all cases the slip for zero thrust was specially determined by a set of runs in which, at constant speed, the revolutions were so controlled as to give no thrust. In all cases, except for number two, the slip at which this occurs is seen to be negative, and the thrust at zero slip is positive. This result is well known in a general way, but the present experiments, so far as the author is aware, are the first published in which the point has been made the subject of quantitative determination. The explanation of the apparent anomaly is found in the influence due to the

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thickness of the blade. Independent experiments show, for a body of cross-section like a propeller blade near the root, that due to the stream-line distribution about such a body, the resultant force, when the direction of relative motion is parallel to the plane face, is directed from the plane face inward, or at least in such a direction as to give a forward component in the case of a propeller thus moving. It is not, therefore, until a negative slip is reached with a more pronounced pressure on the back that this forward component is overcome and a zero thrust obtained. It is also notable that this effect seems to be the less pronounced the narrower the blade, so that for number two a zero thrust was found at nearly zero slip. It thus results that in Figs. 17 and 19 the lines showing the relations between thrust and slip for successive values of the area lie, successively, completely underneath each other as the area decreases, and do not radiate from any point, at least within the region covered by the limits of the physical problem.

mum thrust determined corresponding to the formation of a so-called complete column of water, or, more properly, to the formation of a column completely accelerated in all parts. The influence of the back or thickness, however, is such that these results are by no means entirely reliable. Whatever the value of the maximum, however, it is evident that such a limit will exist, and that after the area necessary to its attainment is reached any further increase will give rise to no additional thrust, and quite possibly to a gradual decline. Passing to the other extreme, it is evident that for no area there will be no thrust. Furthermore, all experimental data on resistance lead us to expect that for very small areas the increase in thrust will be nearly proportional to the increase in area. It follows that starting with zero area the thrust will at first vary nearly with the area, but will gradually increase at a slower and slower rate with further increase, until finally a maximum is reached, after which for increase of area the thrust will either remain sensibly con-

Fig 19.

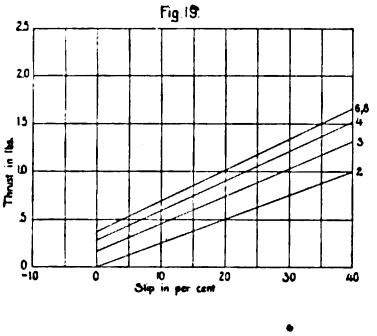


Fig 20.

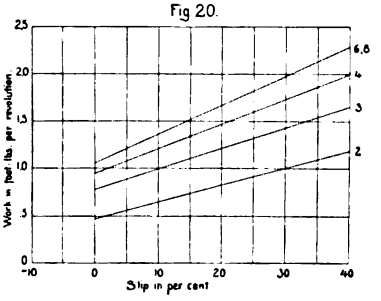


Fig 22

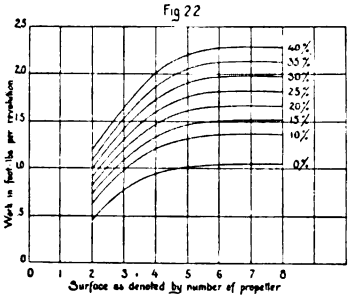
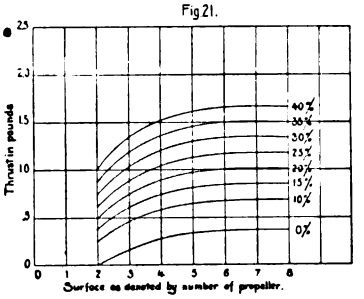


Fig 21.



In Fig. 21 is shown the information especially sought in this series of experiments, the relation of thrust to area. We know that for a given slip there is some maximum thrust beyond which we cannot pass, no matter how much the area. This follows from the fact that, for any given element of the propeller at a given slip, there is a certain maximum acceleration of the water which cannot be exceeded, no matter how much area be employed. By making certain assumptions a value may be assigned to this, and hence a value to the maximum thrust obtainable from any given element of the propeller[3]. By a process of approximate integration this may be summed for the entire propeller, and thus a value of the maximum thrust or else slowly decline. The curves of Fig. 21 are seen to be of this character. The maximum thrust for all slips is seen to be for a propeller having the area of number seven, or an area ratio of about .63. The change between numbers six and eight, however, is very slight, and, so far as these experiments indicate, the variation is practically inappreciable.

The general or average ratios between the thrusts of two, three, and four bladed propellers given as the result of Froude's experiments are .65, .865, and 1.00 for areas in the ratios .50, .75, and 1.00. The corresponding ratios here found for the particular pitch ratio 1.3 with four blades and area ratios .18, .27, and .36, or with areas the same as those for two, three, and four bladed propellers, as derived from the data shown

[3] Cotterill, Transactions Institution of Naval Architects, London, Vol. XX, p. 152.

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in Fig. 21, are found to vary somewhat with the slip, as shown by the following table:

Slip.	Ratios of Thrusts for Area Ratios.		
	.18	.27	.36
.10	.43	.78	1.00
.15	.51	.80	1.00
.20	.56	.82	1.00
.25	.60	.83	1.00
.30	.63	.85	1.00
.35	.65	.86	1.00
.40	.66	.87	1.00

The data for the relation between work required and area, for various values of the slip, are shown in Fig. 22, and will require no special explanation.

We come next to the efficiency curves of Fig. 23. These are of great interest and highly suggestive. Taking true slips within the usual working range of .20 to .30, corresponding to apparent slips of, let us say, .10 to .20, the efficiency, as we see, increases with the decrease of area, and *vice versa*. For low values of the true slip, however, the reverse is the case, and efficiency increases with increase of area. For a slip of about .20 with this pitch ratio, efficiency seems to be nearly independent of area. Or, viewed from another standpoint, a propeller of small area is comparatively inefficient at low slips, and does not reach its maximum efficiency until a high value of the slip is reached. This maximum value is, however, higher than that reached by propellers of more area. *Vice versa*, a propeller of large area reaches its maximum efficiency at a lower value of the slip than for less area, and such maximum is less than that for the propeller of the smaller area. Again, the variation of maximum efficiency for variation of area ratio from .18 to .72 is only about 5 per cent, so that variation of area ratio within this range has comparatively slight influence on the efficiency.

The maximum efficiencies herein determined are slightly less than the value 69 per cent given by Froude for four blades and area ratio .36. The cause of this difference I am at present unable to explain.

In Fig. 24 the same data relating efficiency to area is differently presented. It results from Fig. 23 that if there be no limit on diameter or revolutions, the conditions likely to give the best efficiency are those of low area ratio and high slip, sufficient size and revolutions being provided, of course, to give the necessary thrust. With electric motors or steam turbines, where the revolutions are naturally high, such a propeller may the more readily be selected, and probably, in such cases, propellers of this character and worked at high values of the slip will be found most efficient so long as the conditions are avoided within which cavitation may be likely to occur.

No attempt will be here made to reduce the data found in the present series of experiments to the most convenient form for purposes of design. The incomplete character of the data relative to the problem as a whole makes such a step inadvisable in advance of the completion of the other series of experiments. Remembering, however, the relation assumed between revolutions, diameter of propeller, and useful work, the data shown in the various curves might be used for the design of propellers of the particular pitch ratio 1.3, but naturally of no other.

In conclusion, it may be well to again point out that the data herein contained relates to pitch ratio 1.3, and the conclusions of the present section must be understood strictly as applying to this value of the pitch ratio only.

Construction and Trial of Knapp Roller Boat.

MONOCYCLE.

N Lake Ontario a "roller boat," the invention of a Canadian named Knapp, had a trial trip recently. In this boat the principle of the monocycle is applied to a vessel floating in water, and by this the inventor, according to report, expected to revolutionize the modern method of water transportation. The boat was built in Polson's shipyard at Toronto, local capitalists furnishing the money. The accompanying photographic reproductions show the boat in course of construction in the yard, also when completed, and as she appeared afloat while being towed to the trial course. The view of the boat building shows the method of construction of the "hull," which consists of two concentric cylinders, the outer of which is 110 ft. long and 22 ft. dia. The inner cylinder is 15 ft. dia., and slightly longer than the outer, each end being in shape the frustum of a cone. At each end of this inner cylinder there are several steel rails, or tracks, extending around the inner circumference, and securely fastened to the inner shell. Upon each set of tracks there is a platform with flanged wheels carrying a boiler and engine, the latter connected to the supporting flanged wheels by gears. The smoke pipes of the boilers are carried out and up at the ends of the cylinder. On the outside of the outer cylinder there are sixteen paddles, or fins, 15 ft. long and 8 in. deep, which are riveted to the shell. These form an angle with the radius of the cylinders, so that when the boat moves forward they enter the water at an angle, after the manner of a feathering float. When the "ship" is afloat and the engines are put in motion the immediate tendency is for the platforms to climb up the inside of the inner shell on the tracks already referred to. The outer cylinder, however,

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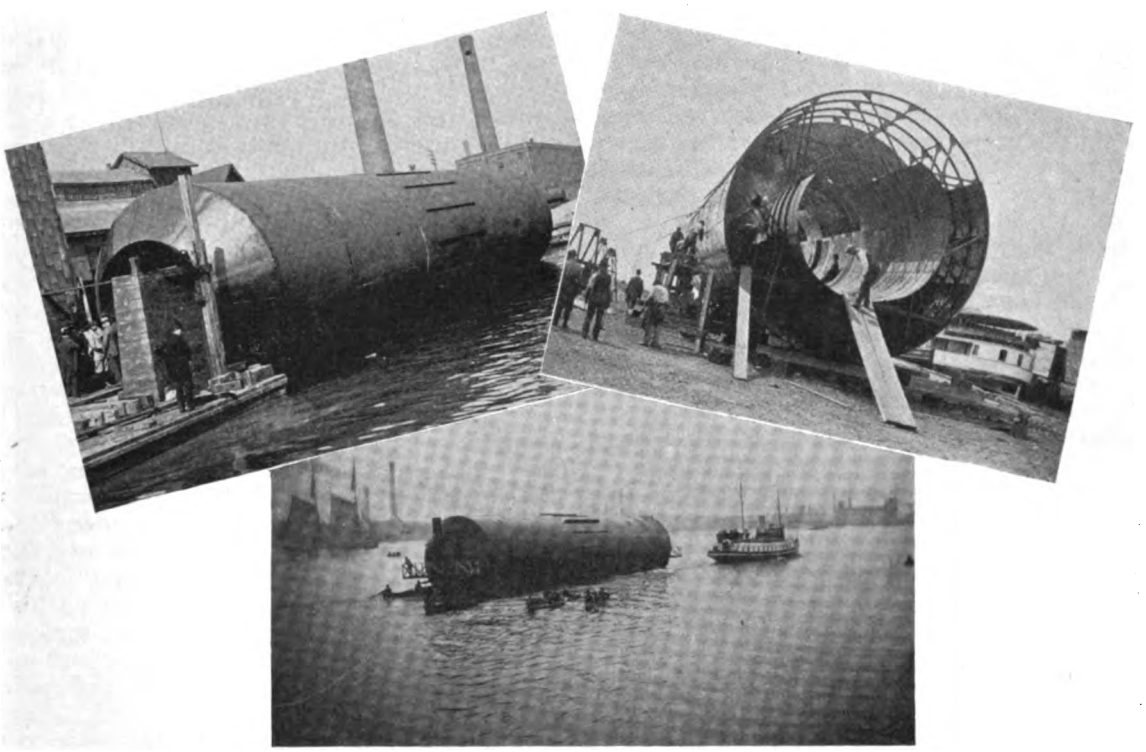
being afloat, and free to move in the water, commences to revolve and continues to do so as long as no serious obstruction is offered, and thus the boat "rolls" over the surface of the water. This is assuming that the vessel is moving in still water. How it would behave in a cross sea, or how long it would take for a wave to break over the smoke pipes and drown out the fires, has not been demonstrated so far as we can learn. In the Knapp boat there is an observation gallery at each end which is hung from the inner platform.

Steering is effected by the use of large tail boards situated one on each side below the platforms. On the trial trip a speed of six miles an hour is said to have been made when the cylinder was turning six revolutions a minute. According to statements put in circulation during the time the boat was building, a speed of as high as 88 ft. per second was counted upon. Passenger accommodation in this form of boat is intended to be provided for in interior cabins built upon the central platform. The space between the inner and outer shells is made water-tight to give the necessary buoyancy.



KNAPP ROLLER BOAT DURING CONSTRUCTION AND AFLOAT.

Recent mishaps to steamships in which the electric lights have been extinguished by water flooding the dynamo rooms have moved the British Board of Trade to recommend that the lighting plants be installed at such a height in the vessel as to prevent such a contingency. Here plants are usually placed in the engine room.

ON THE PROGRESS OF THE STEAM TURBINE FOR MARINE PROPULSION.*

BY HON. CHARLES PARSONS.

The want of a fast running engine for driving dynamos presented an immediate field for the application and development of a suitable steam turbine engine. The advantages of a steady running engine having no reciprocating parts, of small size and extreme lightness, were sufficiently obvious, provided that fairly economical results as to steam consumption could be realized. The highly economical results obtained from water turbines gave hopes that, provided suitable conditions could be arranged, similar efficiencies would be obtained with steam as with water, and, assuming this to be possible, it would naturally follow, after taking all other losses into account, that the steam turbine would be more economical in steam than the piston engine. These possibilities, and the interest of applying a practically new method for motive power purposes, led us to build an experimental engine of 10 horse power, coupled directly to a dynamo. For practical reasons it was, however, necessary to keep the speed of rotation of the turbine as low as possible, and also to construct the dynamo to run as fast as possible, so as to couple the turbine directly to it; and in order to obtain the necessary conditions for steam economy, the turbine was

* From a paper read before the Institute of Marine Engineers, London, 1897.

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made what is called compound, or, in other words, a series of successive turbine wheels were set one after the other on the same spindle, so that the steam passing through them one after the other, the fall in pressure being spread over the series of turbines, should be gradual, and the velocity of the steam nowhere more than was desirable for obtaining a high efficiency for each turbine of the series.

The Turbine Motor.

The turbine motor consists of a cylindrical case with rings of inwardly projecting guide blades, within which revolves a concentric shaft with rings of outwardly projecting blades. The rings of blades on the cylinder nearly touch the shaft, and the rings of blades on the shaft lie between those on the case, and nearly touch the case. There is left between the shaft and the case an annular space, which is fitted with alternate rings of fixed and moving blades. Steam passes first through a ring of fixed guide blades, by which it is projected in a rotational direction upon the succeeding ring of moving blades, imparting to them a rotational force; it is then thrown back upon the succeeding ring of guide blades, and the reaction increases the rotational force. The same process takes place at each of the successive rings of guide and moving blades. The energy to give the steam its high rotational velocity at each successive ring is supplied by the drop in pressure, and the steam expands gradually by small increments. In a moderate size turbo-motor there may be from 30 to 80 successive rings, and when the steam arrives at the last ring the expansion has been completed. On the left side of the steam inlet are the dummy or rotating pistons, which are fixed to and rotate with the shaft. On their outsides are grooves and rings which project into corresponding grooves in the case. By means of the thrust bearing of the motor, the longitudinal position of the shaft is adjusted, and grooves and projecting rings kept nearly touching, so as to make a practically tight joint. The object of these pistons is to steam balance the shaft and relieve end pressure on the thrust bearing. With compound condensing turbines a steam efficiency comparable with the best compound or triple expansion condensing engines was at length reached, and it was then resolved to test the application of the compound turbine to the propulsion of ships, for which purpose it seemed well suited, provided that as good an efficiency could be obtained from fast running screw propellers as with ordinary ones.

Torpedo Boat Turbinia.[1]

In January, 1894, a syndicate was formed, and a boat was designed for this purpose. The Turbina—as the boat is named—is 100 ft. in length, 9 ft. beam, and 44 1-2 tons displacement. The original turbine engine fitted in her was designed to develop upwards of 1,500 actual horse power, at a speed of 2,500 revolutions per minute. The boiler is of the water-tube type, for 225 lb. per sq. in. working pressure, with large steam space and large return water legs, and with a total heating surface of 1,100 sq. ft. and a grate surface of 42 sq. ft. Two firing doors are provided, one at each end. The stokeholds are closed, and the draught furnished by a fan coupled directly to the engine shaft. The condenser is of large size, having 4,200 sq. ft. of cooling surface. The circulating water is fed by scoops, which are hinged and reversible, so that a complete reversal of the flow of water can be obtained should the tubes become choked. The auxiliary machinery consists of main air pump and spare air pump, auxiliary circulating pump, main and spare feed pumps, main and spare oil pumps, also the usual bilge ejectors; the fresh water tank and hot well contain about 250 gallons. The hull is built of steel plate, of thickness varying from 3-16 in. in the bottom to 1-16 in. in the sides near the stern, and is divided into five spaces by watertight bulkheads. The deck is of steel plate, 1-16 in. to 1-8 in. in thickness. The approximate weights are: Main engines, 3 tons 13 cwts.; total weight of machinery and boilers, screws and shafting, tanks, etc., 22 tons; weight of hull complete, 15 tons; coal and water, 7 1-2 tons; and total displacement, 44 1-2 tons. Trials were made with screws of various patterns, but the results were unsatisfactory, and it was apparent that a great loss of power was taking place in the screw. Owing to the cavitation[2] of the water, the matter was then thoroughly investigated, theoretically and experimentally, and it was finally determined (as the best course to overcome the difficulty) to subdivide the turbine motor into separate compound turbines. Consequently, the single compound turbine engine was removed from the boat and replaced by three separate compound turbines, directly coupled to three shafts, working in series on the steam, the turbines being the high pressure, intermediate, and low pressure, and designed for a complete expansion of the steam of hundredfold, each turbine exerting approximately one-third of the whole power developed, the three new screw shafts being of reduced scantling. By this change the power delivered to each screw shaft was reduced to one-third, while the division of the engine into three was favorable to the compactness and efficient working of the turbines. The total weight of engines and the speed of revolution remained the same as before. The effect on the screws was to reduce their scantling, and to bring their conditions of working closer to those of ordinary practice. The thrust of the propellers is balanced by steam pressure in the motors. At all speeds the boat travels with an almost complete absence of vibration, and the steady flow of steam to the motors appears to reduce the liability to priming; at any rate, no sign of this has yet occurred with ordinary Newcastle town water. No distilling

[1] See also June issue, page 6, and July issue, page 11.

[2] See October issue, page 16.

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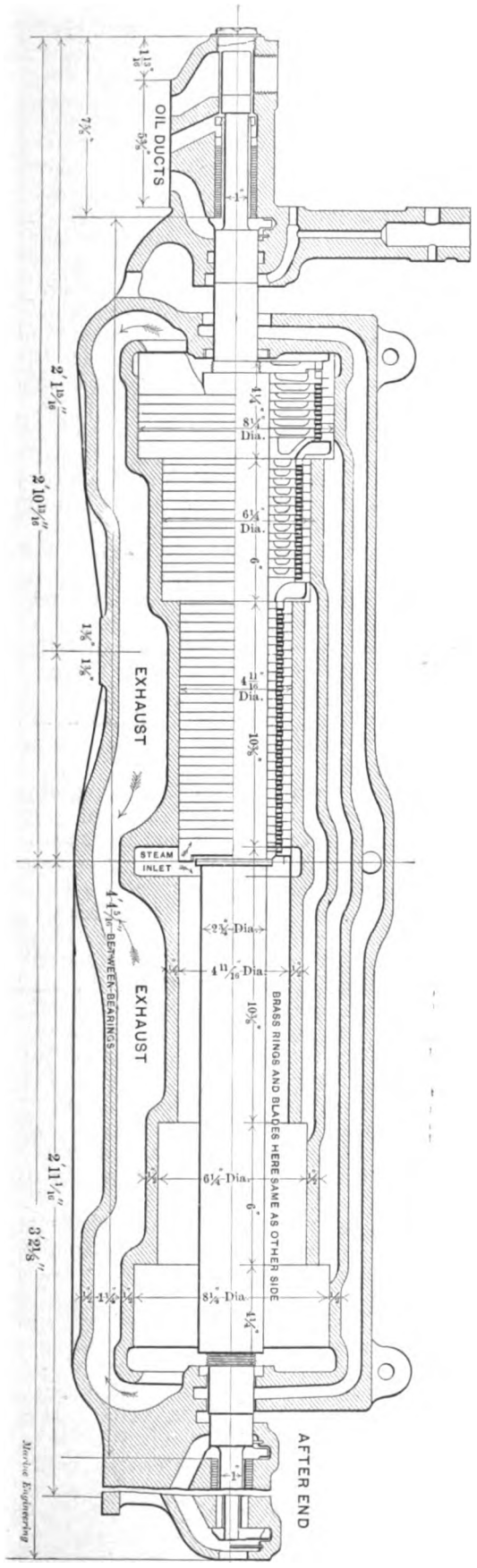

SECTIONAL SKETCH OF 60 H. P. "SINGLE COMPOUND" TYPE PARSON'S PATENT TRIPLE-EXPANSION STEAM TURBINE.

apparatus has yet been fitted. The boat has been run at nearly full speed in rough water, and no evidence of gyroscopic action has been observable, though such a result would be anticipated from the known small amount of these forces under actual conditions; indeed the Turbinia has so far proved herself an excellent sea boat.

For the purpose of going astern a small reverse turbine is used. This turbine has hitherto been of an inefficient form, and has constituted a part of the low pressure motor; the power consequently that has been developed has been very small, and has given an astern speed of three knots. A powerful reversing motor is, however, now being fitted of similar construction to the ahead motors; its weight is three-quarters of a ton, and it is estimated that the astern speed will then exceed 10 knots. The turbine will be permanently connected to the central propeller shaft, and its casing will be connected to the condenser, and the amount of power spent in turning it when going ahead will be insignificant. In June last the Turbinia steamed from the Tyne to Harwich at the average speed of twelve knots, and from Harwich to Cowes at the average speed of sixteen knots. During and after the week of the Spithead Review she was run at speeds up to 34 1-2 knots, estimated from the curve of steam pressure and speed, and ample steam is provided by the boiler at the highest speeds hitherto reached.

Results of Trials.

In April a series of trials were made by Professor J. A. Ewing, and the following paragraphs are extracts from his report, which comprises, I believe, the most complete set of investigations made on the working of a small fast vessel: "The mechanical friction of the turbines is particularly small, and the work spent on friction is not materially increased by increasing the range of expansion. This allows the steam to be profitably expanded much farther than would be useful or even practical in an engine of an ordinary kind. Apart from questions of friction, the addition of weight and bulk to allow for this extended expansion would be enormous in the ordinary engine; in the turbine it is very moderate. Steam is expanded nearly two hundredfold in the Turbinia, and this is accomplished with engines which are much lighter than reciprocating engines of the same power, although in these the expansion would be much less complete. Rough weather was met with in some of the trials, and I had the opportunity of seeing that the Turbinia is for her size a good sea boat. The machinery worked with perfect smoothness, the screws did not race, and the bearings remained perfectly cool throughout. From first to last during the whole of the trials there was no hitch whatever or difficulty of any kind in the action of the turbines. Some twenty trial runs in all were made under various conditions as to speed, the range of speeds tested extending from 6 3-4

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knots to 32 3-4 knots. Fullspeed trials were made on April 10, the boat having then been in the water for fully a fortnight. Two successive runs on the measured mile, in opposite directions, in smooth water and at the slack of the tide, gave the following data:

Time on the mile	109 4-5 secs.	110 secs.
Corresponding speed in knots	32.79	32.73
Mean speed in knots	32.76	
Revolutions per minute of high pressure and intermediate shafts		2,230
Revolutions per minute of low pressure shaft		2,000
Steam pressure in boiler by gauge		210 lb. per sq. in.
Steam pressure on admission to high pressure turbine		157 lb. per sq. in.
Greatest pressure in stokehold by water guage		7 1-4 in.

The speed reached during this trial, 32.76 knots in the mean, is, I believe, the highest recorded for any vessel. It is greatly in excess of the speed hitherto reached in boats so small as the Turbinia. It is clear, then, that the exceptional speed developed in the Turbinia has been achieved without sacrifice of any economy, and that the substitution of turbines driving high speed screws in place of reciprocating engines driving screws of much more moderate speed is not attended with increased consumption of steam so far as fast running is concerned."

Turbines for Large Vessels.

In conclusion, the application of the steam turbine principle to fast ships in general, including passenger vessels, Atlantic liners, and ships of war, would appear to present no special difficulties. It may be said, generally speaking, that the larger the scale on which the engines are made the simpler the construction and the higher the steam efficiency, and the lower the speed of rotation. In sizes hitherto constructed, the largest being the engines of the Turbinia, this has been found to be the case. In applying turbine engines to a large passenger vessel or warship of, say, 30,000 I. H. P., probably four screw shafts with two screws on each shaft would be adopted. Each of the four shafts would be driven by one compound turbine at a rate of between 400 and 700 revolutions per minute, and the turbines would consist of the high pressure, the intermediate, and two low pressure, each turbine developing approximately one-quarter of the total power. The screw propellers would be about one-half the diameter of ordinary twin screw propellers, and the aggregate blade area would approximate closely to ordinary practice. With such engines the consumption of steam per propulsive horse power would probably be less than that found in the mercantile marine, and considerably less than that found in engines of war vessels, where space and other conditions must necessarily be considered. There is also no limitation in steam pressure in the case of turbines, other than those imposed by the boilers; and it is probable that in conjunction with water tube boilers higher pressures than those at present usual would be generally adopted. With turbine engines in passenger vessels there would arise no questions of vibration from machinery or propellers.

LOADING OF VESSELS ENGAGED IN "KLONDIKE" TRADE ON THE PACIFIC COAST.

BY JAMES S. TYLER.

The growth of the Alaskan passenger and freight traffic on the Pacific side was spontaneous. Prior to the discovery of gold on the Klondike and its tributaries the bulk of the carrying trade between St. Michaels, Juneau, and Alaska ports was controlled by the Pacific Coast Steamsip Co. and the Alaska Commercial Co. The former corporation confined its field of operations to Southeastern Alaska, with Juneau as the northern terminus of the line. The Alaska Commercial Co. operated steamers to St. Michael Island during the spring and summer months, calling at Unalaska and occasionally at other ports.

The steamers Bertha, Excelsior, and Dora composed the little fleet that handled the freight trade of the Yukon between San Francisco and the mouth of the river. These vessels connected with the river boats operating between St. Michaels, Dawson City, and intermediate points. The combined fleets of coast and river craft were barely able to accommodate the business tendered them, and each season found them struggling to transport sufficient provisions and general merchandise to the mining districts. There were frequent rumors of an improved service, which never materialized. Increased facilities were not provided until the Klondike boom suddenly awoke the Pacific coast.

When the steamer Excelsior brought the pioneers of Dawson and their sacks of gold to San Francisco there was but one transportation line—the Pacific Coast Steamship Co.—prepared to advertise first-class accommodations for passengers and space for freight. The Alaska Commercial Co. announced almost immediately on learning that a rush was about to be started toward the mines, that it was not in the Alaska trade for the purpose of carrying passengers or "outside" freight to Dawson. Its steamers, the management averred, would accept only a limited amount of merchandise for Dawson, and sign only a few passengers. The Pacific Coast Steamship Co. was prepared to handle a large volume of business, but those who arranged with that corporation had to face the arduous trip from Juneau over the Chilcoot Pass.

As the gold fever became more virulent the ship owners attempted to accommodate the increasing host of prospectors. Every available steam vessel was put into commission, and craft which had lain idle for months found many prospective purchasers who were willing to pay the original cost of the ships. The fleet offered for charter consisted mostly of steam schooners, colliers and a few passenger craft. The local coast trade was dull, and the Humboldt Steamship Co. forsook its competitive route to Eureka, withdrew the new and well-appointed wooded propeller steamer Humboldt, leaving rivals in full possession of the North California local trade.

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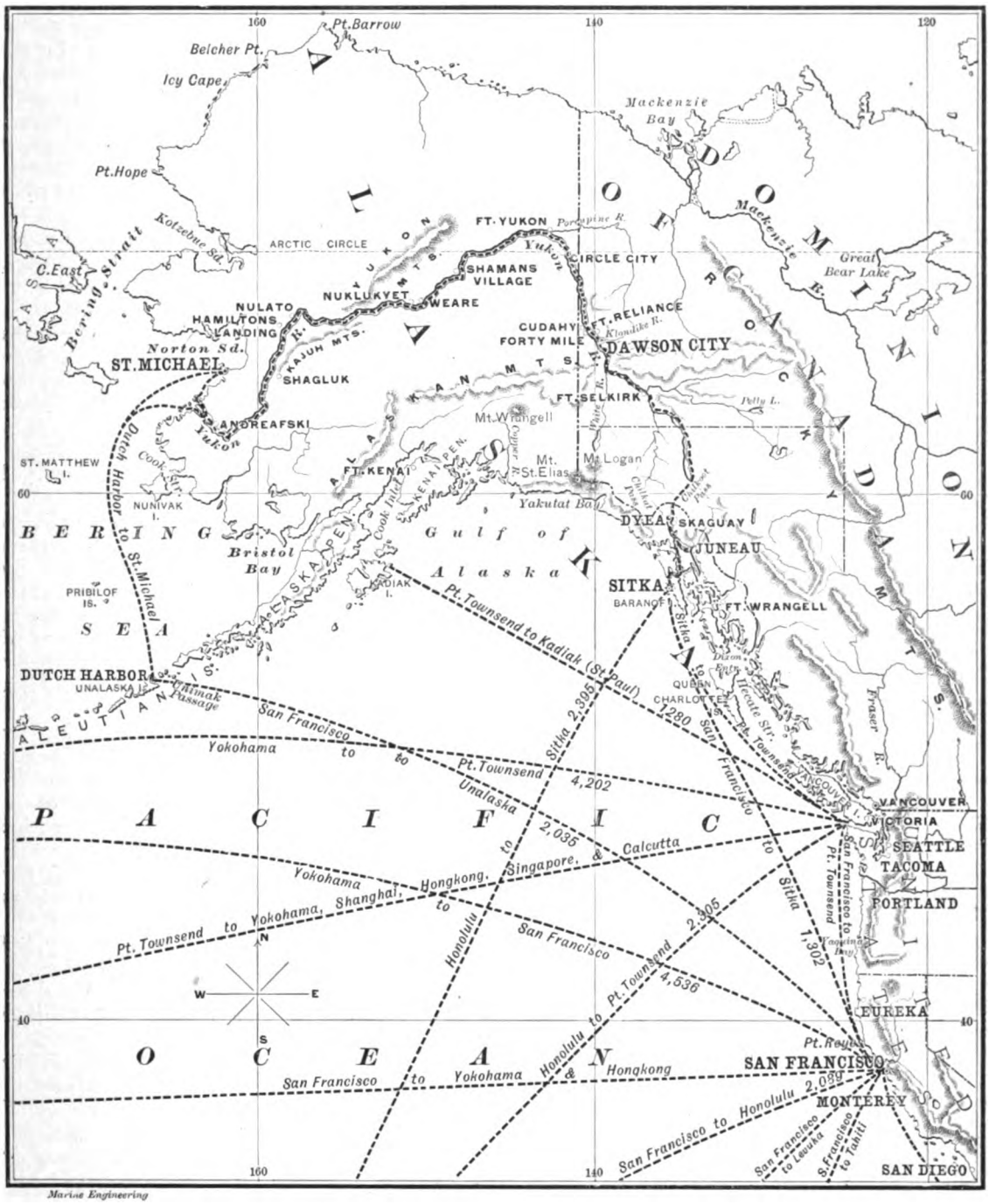
The Humboldt and the Farallon—the latter was taken off the Yaquina Bay route—were, with the exception of the steamers Queen and George W. Elder, the best adapted of available vessels for the Alaskan service. The Queen was the way lines, with terminals at Portland. The vessels out of San Francisco connecting with the Queen were the Umatilla and Walla Walla, both ships of 2,168.37 tons register, modern in every repect, and the steamer City of Puebla, of 1,713.90



Marine Engineering

ROUTES OF WATER TRANSPORTATION FROM PACIFIC COAST PORTS TO THE YUKON GOLD FIELDS.

(Compiled by Marine Engineering from the latest official and other authentic sources.)

regular Alaskan tourist vessel which connects at Puget Sound for Juneau, Wrangell, and other points north of the British Columbia boundary.

The Elder was placed on the berth at Portland, Ore., to handle the Northwestern traffic of railtons net, the swiftest of the Pacific coast passenger fleet.

The Humboldt and Farallon were placed on the berth for St. Michaels and Skaguay, respectively. The Farallon, though a small vessel,

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252.37 tons, 175 horse power, did not go out of port overloaded, as was reported in the Eastern press. The Humboldt sacrificed passenger accommodations for freight, and, besides, carried on her 'tween decks forward machinery for a 125 horse power river steamer and the wood-hull sections. Her decks were hampered with lumber and cases of general merchandise. The attention of the local Inspectors of Hulls and Boilers was directed to the ship. Although to the eye the ship seemed unreasonably burdened, it was found that the stevedore had complied with the regulations governing steam vessels carrying passengers, and had left wide gangways open fore and aft on the main deck. The Farallon sailed with a two-third cargo and fifty passengers. She was provided with light-draft boats for transferring cargo at Skaguay, but no other freight was stowed above decks.

Public attention was then directed to the steam schooners, the collier Willammette and the sailing vessels. The craft of the steam schooner class which were engaged are herewith tabulated according to their tonnage:

South Coast	171.35
Navarro	209.31
National City	220.99
Noyo	229.84
North Fork	244.04

The Willammette is a steel collier of 1,200 tons. She had to be overhauled to accommodate passengers. Rows of bunks, regulation three tiers high, were built lengthwise in her hold. At San Francisco and Seattle—she stopped at the latter port before starting for the Arctic—about 500 passengers were signed. A large quantity of freight was carried, but the vessel was not dangerously overloaded. It was the alleged crowded and overloaded condition of this ship and the National City which formed the basis of much of the adverse comment that was wired East concerning the "unseaworthiness" of many of the San Francisco vessels placed on the Alaska route. Inspector of Hulls Bolles and Inspector of Boilers Phillips made a thorough examination of the Willammette before she left San Francisco and decided she was seaworthy; that her hull was sound and her machinery in good repair. The vessel, though staunch of hull, developed weaknesses in her engineer's department. When she was several miles outside of San Francisco Bay her boilers choked and portions of her machinery showed signs of failure. No technical description of the troubles could be obtained, as the owners were extremely reticent. It was stated on good authority after the steamer reached Seattle that the choking of the boiler tubes was due entirely to poor fuel, and that the defects in machinery were caused by too hasty work during repairs at San Francisco. When the vessel was hove to off Point Reyes substantial repairs were made and the trip north continued. On arrival in the Sound better coal was placed in the bunkers and the rest of the voyage was completed without further accident.

The steam schooner National City was also most severely criticised by the press. The inspectors examined the vessel, but apparently did not settle the case on its merits. Inspectors Bolles and Bulger argued that the vessel's cargo had been well stowed, and added: "The question of the loading of ships is clearly without the jurisdiction of this board. The Revised Statutes of the United States governing steam vessels provide that inspectors should see that a sufficient number of life-rafts, life-boats, and life-preservers are provided for the use of passengers, and that gangways are kept open fore and aft of the ship." The writer made a careful examination of the ship in company with several ship owners who were anxious to satisfy themselves personally concerning the manner of loading. The steamer has 33.8 ft. beam, but the steam launch Hettie B., for Yukon work, and a scow barge 20 ft. wide by 40 ft. long, projected outbound at the port and starboard sides, bearing the steamer well down by the head. The Hettie B. rested on a cushion of sacks of grain piled three sacks high. Forward there was erected a temporary deckhouse of rough boards and 3 in. by 4 in. scantlings, intended to house five or six of the crew. The barge completely blocked the way to the forecastle-head and the 'tween decks forecastle. The starboard and port poop ladders were removed and in their places there were secured two 4,000-gallon water tanks. The poop deck was reached by a companion ladder placed alongside the starboard tank. Lumber for several houses was piled rail-high amidships. The vessel was loaded well over her water line, and the main deck was nearly awash forward of the after house.

The steamer South Coast was loaded in a manner almost similar to the National City; but with these two exceptions the coast fleet was not in an "unseaworthy" condition. It should also be borne in mind that the season of the year during which the San Francisco fleet started north only calm seas and light airs are found. The North Pacific during the summer is as smooth as a lake from Cape St. Lucas to the Bering.

San Francisco ship owners are making active preparations to handle the spring passenger and freight trade between this port, St. Michael and Juneau. The Alaska Commercial Company, Alaskan Development Co., Pacific Coast Steamship Co., and Pacific Steam Whaling Co. have already commenced to lay their plans for the future. Seattle and Portland are not behind. The Dawson City Transportation Co, organized by a number of Eastern and Washington State capitalists, has arranged for new steamers to be built at coast shipyards. On this side of the continent there is no doubt that thousands of dollars will be expended in new tonnage. There is very little, if any, available tonnage for charter on the Pacific side. Nearly every steam vessel of any capacity is engaged. The demands of the Hawaiian and North Pacific coast trade have been great, and those who are interested in fostering the Alaskan

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business have had difficulty in securing options on ships.

The Alaska Commercial Co. has secured the Alliance, 213.52 tons, which was about the only vessel fitted for the passenger and freight trade offered here. The Alliance can accommodate about fifty passengers by making some additions to her deck houses. She will, however, be used principally as a freight boat, as the company has just called for specifications from the Union Iron Works for a 2,500-ton passenger steamer, modern in every particular, and especially adapted to the business of carrying gold-seekers. Plans are now being worked out.

The Pacific Coast Steamship Co. has just purchased the Atlantic Coast steamer Curacoa, 825.21 tons, 1,200 horse power, which is a comparatively new vessel, built at Philadelphia in 1895. At the Union Iron Works they will also cause to be built a steamer to be called the Senator, which, the company states, will replace the Orizaba on the Mexican route; but it is believed in shipping circles that the vessel will be used as an Alaskan trader, as the Mexican trade does not justify the employment of so fine a vessel. The Senator is intended to be a 16-knot boat. She will be 288 ft. long over all, 38 ft. 2 in. beam, 21 ft. depth of hold, and will carry 1,500 tons dead weight on a draft of 15 ft. The engines will be triple expansion, of 1,850 horse power, with the cylinders 23 in., 26 in., and 60 in. dia. by 36 in. stroke. Accommodations for fifty first-class and fifty second-class passengers will be provided. There will be electric lights throughout the ship.

The Pacific Steam Whaling Co. has purchased one steamer in New York and will soon bring her around the Horn. The company is looking for another vessel, and may possibly place an order soon with an eastern shipyard. The name and description of the ship purchased is kept a secret. The company has a small steamer named the "Walcott" on the Copper River, San Francisco route.

The Seattle Dawson City Transportation Co. will have two first class river steamers on the Yukon. One of the boats is now building at Nowell's Mill, Puget Sound. The boats will be 230 ft. long., 30 ft. beam, 4 1-2 ft. depth, and will have 10 in. draft when light and 2 ft. draft when loaded. Each will carry 200 tons of freight.

The Alaska-Yukon Co. has left a contract to Moran Brothers, of Seattle, for twelve river steamers, two stern wheel towboats, and twenty-four barges. Six of the steamers will be 260 ft. long, 35 ft. beam, and 2 ft. draft when loaded. Each barge will be supplied with a steam winch and two cargo derricks for handling freight.

Pacific coast investors are convinced that a fleet of twenty river boats will be able to handle all the Yukon business. No vessels for Alaskan rivers are building at San Francisco. The Hudson Bay Company may place an order at a near date for a river steamer for the Stickeen River route.

PITTSBURG AND CINCINNATI PACKET LINE STERN WHEEL STEAMER QUEEN CITY.*

BY BERT L. BALDWIN, M. E.

Other interesting apparatus peculiar to these vessels is the 7 in. by 14 in. nigger engine, geared to winding drums, which are placed over the main forward hatches, and are intended for handling heavy freight, and the steam capstan, which is used in handling the landing stage, and for straining the lines when necessary to spar over a shoal or warping in a bow or stern line. The landing stage is strictly a Western river device, there being but few wharf boats at the small towns, and it is impossible to use piers on account of the great variation in the water level. At the city of Cincinnati, for instance, it is usual, in the early spring time, to have 50 ft. of water over the low-water mark, and it has gone beyond the 71 ft. mark on occasions. The landing stage is 45 ft. in length by 6 ft. in width, having deep white pine gunwales and oak beams and floor. It is properly ironed to resist wear and increase its stiffness, as well as having projecting trussed brackets, for handling. This is accomplished by tackle, supported by the stage boom, which terminates in a stage span and spreader, so as to give a clear passageway over the stage. On many steamers there are two of these landing stages, handled by side derricks, which are also used in handling the spars and for loading freight upon the upper decks, but on the steamer Queen City one central mast, with its boom and galvanized steel standing rigging, is light and occupies less room.

The steamer is also equipped with derricks on either side of the mast, and seated in hemispherical deck sockets. Each derrick is supplied with a heavy iron-pointed spar, and suitable running rigging, to be used where necessary, for the purpose of holding the steamer away from the bank, or for sparring off bars or over shoal places. In using the spars, they are set on either side of the steamer's bow, their falls are connected to heavy deck fastenings, which are reinforced by lashings that extend over the guards to the pendent straps, situated on the bows above the water line, and through bolted to the frames and strakes. The fall lines lead through snatch blocks, and are strained by the capstan until the bow is raised clear of the obstruction, when, by the aid of the main engines, the steamer is backed off or forced ahead, according to circumstances. In the illustration of the Queen City [1] the derricks will be noticed, but the spars were stowed away under the boiler deck at the time the photograph was taken.

One detail which should not be overlooked, which belongs to the mechanical equipment of the steamer, is the chimney-handling gear. As will be noticed, the upper portion of the chimneys is

* Commenced in October issue.

[1] See October issue, page 7.

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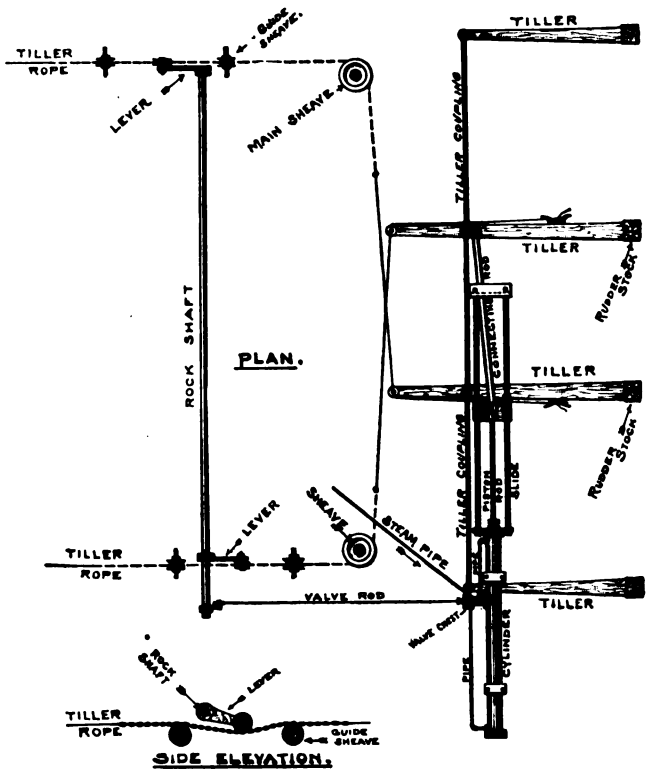
hinged so as to be lowered when it is necessary to pass under the low bridges. This is accomplished by gear on the hurricane deck just aft of each chimney, and consists of 2 1-2 in. dia. square thread screws working in suitable nuts, which are seated in heavy pipe braces (into which the screws telescope) that are hinged to the upper section of each chimney. The screws are operated by hand cranks through miter gears, as shown, and by slacking away the forward chimney guy lines the gear is ready for operation. All of the various systems of water and feed piping are arranged with long radius bends, similar to the main steam piping, so as to allow for expansion, contraction and twisting; and all pipes that carry steam or hot water are covered by high grade sectional pipe covering.

The steam steering gear is in the engine room. It is made by Crawley & Johnston, of Cincinnati, and is so simple in its construction and effective in operation that it deserves attention. The engraving on this page illustrates the principle of this steering apparatus, which consists of an 8 in. dia. steam cylinder, secured to the underside of the boiler deck, provided with a cross head, working upon cylindrical slide bars, and coupled to one of the main tillers by means of a substantial connecting rod. The valve which regulates the admission and release of steam is operated by a small lever upon a cross rock-shaft. This rock-shaft has levers near each end, which carry small sheaves that are arranged so that they both depress a short portion of the main tiller rope. When the pilot turns his wheel and throws a strain upon one tiller rope, and at the same time throws a certain amount of slack in the other rope, it acts upon the levers, causing one to rise and the other to fall, which turns the rock-shaft, and, through the small lever and valve rod, operates the valve, admitting steam to one end, and opening the exhaust at the other end of the cylinder. As long as the pilot continues to turn his wheel, the valve will remain in this position and the piston will continue to move in the one direction; but as soon as the pilot wheel stops revolving the continued motion of the piston takes up the slack on the one side and throws it ahead on the other, causing a reverse movement of the valve, which, if continued, allows steam to enter at the opposite end of the cylinder, forming an effective cushion. By this arrangement the pilot has very little more than the friction of his wheel to overcome, while the steam gear performs the laborious portion of the work, and automatically resists all strains which come upon the rudders, as these strains act upon the tiller ropes and steam valve, in a manner similar to what has just been cited, in case of the piston overrunning its intended stroke. The extreme simplicity of the apparatus recommends it, and makes it interesting to boat owners who would not consider the question of equipping their vessel with the usual type of steam quartermaster, on account of its complications and high first cost.

The non-condensing main engines drive the paddle wheel at a speed of 24 rev. per minute, when the boilers are worked to the limit allowed by the Government, with steam at 166 pounds above the atmospheric pressure. The engines under these conditions would cut off steam at 3-8 of the stroke, which would show a mean effective pressure of about 100 lbs. per sq. in. upon each piston, and develop collectively 1,024 horse power, and when the engines are worked to the later point of cut-off they will develop over 1,400 horse power. By forcing the fires so as to maintain a high boiler pressure, the Queen City attains a maximum speed of 14 miles per hour against the current, which runs from 2 1-2 to 3 miles per hour, according to the stage of the river. This, of course, is when the steamer is working light with very little freight. She is registered at 624 23-100 tons. Under ordinary working conditions she draws 32 in. of water



CRAWLEY AND JOHNSTON STEERING GEAR.

throughout her entire length, while, when loaded to her maximum carrying capacity, with 1,400 tons of freight, she draws 5 ft. of water at the stern and 9 ft. at the bow. This may seem a peculiar manner in which to load a boat, but experience has proved it to be a correct plan where heavy currents are to be encountered, and to obtain the most satisfactory results from the stern wheel.

The boilers in a Western river steamer are so limited in size by the many restrictions that it is a surprise to almost every engineer, who has occasion to make an investigation, to discover

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how well the boilers meet the excessive demands for steam that are made upon them. It has just been stated that the engines of the Queen City indicate over 1,000 horse power when working under full pressure and at their usual point of cut-off. In addition to this, there is a 30 horse-power electric light engine, as well as steam pumps, steam steering gear, and the injectors, which all use steam at the same time. The main engines are as economical as the Corliss, or any other well-proportioned automatic cut-off engine working under the same range of cut-off; but this efficiency is, of course, not possessed by the small slide valve engine, the steam pump, or the large injectors, so that it is a conservative estimate to rate these boilers as supplying 1,100 horse power in steam. The actual effective heating surface of each boiler is about 580 sq. ft., which gives 2,320 sq. ft. heating surface for the entire battery of four boilers, or less than 2.11 sq. ft. heating surface per indicated horse power. The boilers are usually worked with forced draft, produced by the exhaust discharging through contracted nozzles in the chimneys. This is very necessary at certain stages of the river when the chimneys are hinged back to clear bridges, though this blast, while increasing the amount of water evaporated per unit of heating surface does so usually at the expense of the coal pile.

It is to be regretted that the steamer is not arranged so that a systematic evaporative test could be made to determine the exact efficiency of these boilers, and it is to be hoped that this may be done in the near future. At present we must be satisfied with the practical results obtained, which show that the boilers are under steam continuously for six days and fifteen hours each week, which include a round trip of about 2,000 miles steaming and handling freight, during as well as at each end of the voyage. In this period of time an average of 3,800 bushels of Pittsburg coal is consumed, which includes the amount of coal burned in supplying steam to all of the various auxiliary engines, as well as the main engines, and also supplies a vast amount of steam to the chime of whistles, which is used often and long in river service.

The most remarkable feature in connection with the amount of fuel consumed by this steamer upon her average trip is the fact that she uses no more coal, with her high pressure non-condensing engines, than is used by the steamer Virginia, which is a twin sister as far as the general dimensions and model are concerned, with coupled tandem compound condensing engines, having steam cylinders 15 in. and 33 in. by 84 in., with independent air pumps and condensers for each engine, which easily maintain a vacuum of from 24 to 26 in. To be very accurate in this statement, the actual cost of fuel per "average round trip" of the steamer Queen City amounted to 75 cents more than that for the Virginia, while the former boat made the faster time.

With the exception of a few weeks during the fall of the year, when the upper portion of the Ohio River is very low, the Queen City makes regular trips between Pittsburg and Cincinnati, leaving the latter city every Saturday evening, and arriving on the return voyage early in the morning of the following Saturday, her actual running time being six days, over a route which, with the various curves necessary in rounding to in making landings, is equal to a journey of 1,000 miles. This is an average speed of about 7 miles per hour, and includes the time consumed in making fully 100 landings in each direction, as well as the time necessary to take on and put off freight.

Another point, which sounds strange, but one upon which all river men agree, is that a limber boat is much faster than a rigid one, and for this reason a boat becomes faster as it grows old. It has been suggested that this is due to the fact that the limber boat can conform more readily to ground swells produced by inequalities in the river's bottom, but it is claimed upon the other side that the same conditions prove true where there is forty feet of water in the channel, and at stretches where there are no known inequalities that could cause ground swells.

Although one of the strongest points in favor of a stern-wheeled boat is its ability to work well in shallow water, yet if the water is too shallow it increases the resistance on the wheel and causes the engines to labor. For example, with the steamer which has just been described, working over a stretch of river in which the water is 30 ft. deep, the engines will drive the wheel at full speed, and when the steamer strikes into shallow water, which is 10 ft. deep, the engines will commence to labor, and the speed will drop off fully three revolutions per minute, with uniform boiler pressure in each case.

Of late years, most of the river steamers have been built with stern wheels, fully eight of this type to one side wheeler, and to be able to navigate the river properly, the side wheel steamers have been built with disconnected wheels, so that the wheels may be operated independently of each other.

In extreme cases, one may be working ahead while the other is working astern, yet, withal, a good stern wheel boat can turn completely around three times while the side-wheeler is making one turn, the wonderful steering and handling qualities of the stern wheel boats, as well as their great carrying capacity, making them general favorites for river traffic.

A short description of the Cincinnati Marine Railway, where the Queen City and many other well-known boats for the river service were designed and constructed, may prove interesting, as it also bears upon Western river practice. The Marine Railway consists of a series of inclined ways, composed of heavy timbers, securely anchored in position, and extending from the top of the river bank down to a level that is considerably below the low-water mark. There

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are eight pairs of these ways, each of which is equipped with a sliding cradle, the bottom slides of which rest upon the inclined ways, while the framing is so arranged that the upper surface is horizontal. At the upper end of the inclined plane there is a continuous line-shaft, driven by a powerful engine, with clutches arranged so as to operate, through 9 trains of double-worm gearing, heavy winding drums upon which the hauling chains are wound that are connected to the various cradles. By this arrangement of machinery any or all of the cradles can be drawn up or lowered down the inclines simultaneously. A boat in need of repair can be floated over a number of these cradles, and drawn up the inclines until she is high above the water level, and after being properly repaired, lowered until she again rests upon the river. Very often a boat is raised toward the top of the ways, and supported in this position by a separate system of blocking, while the cradles are lowered for the purpose of handling some other craft in need of attention.

At the top of these inclined ways, convenient to the mill room and pattern loft, where timbers for her framing could be machine-shaped and dressed, the steamer Queen City was built upon stocks and suitable blocking, lying parallel to the river with her bow up stream. In this position the hull was built, the various decks and deck house erected, the machinery put in position and connected up, so that when the day arrived for launching she was complete, with the exception of a few finishing touches necessary to complete the cabin. The cradles had been brought into position supporting the entire weight, the blocking removed and the steamer lowered down the ways, until she stood only a few feet above the water level, with a full head of steam upon the donkey boiler, for the purpose of handling the capstan, the pumps, if necessary, and the whistle. With the usual launching ceremony the catches were tripped, and the cradles with their burden shot into the river; the cradles, sinking deep below the surface, allowed the Queen City to float upon the surface of the Ohio, drifting slowly down stream clear of the cradles, and to a landing below the ways; the handling of the boat being regulated by the bow lines.

The designers and builders of these Western steamers deserve both praise and credit for the manner in which they have perfected the methods of construction, which, it is claimed, combines a greater amount of strength with a corresponding degree of lightness than can be found in any other type of marine architecture of corresponding size and carrying capacity.

The Ohio River, from Pittsburg to its junction with the Mississippi at Cairo, Ill., is about 1,000 miles long. The amount of capital invested in the steamboat business is approximately $8,500,000, and the average annual shipments include, freight, 7,000,000 tons, and passengers carried 1,500,000. The value of the freight shipped during 1896 was $250,000,000, in round numbers.

IMPROVED APPARATUS.

Balanced Piston Valve Paddle Engines.

The engraving herewith shows a modern balanced piston valve engine for stern wheel steamers, designed by Charles P. Willard & Co. There has been a great increase of late in the number of light draught vessels built for domestic river trade, and also for shipment to the Klondike. As will be seen by the engraving, the bed plate on which the cylinder rests is continuous and forms the lower cross head slides. The steam chest is placed on top of the cylinder, thus saving a little in the space taken up by the engines in the boat. The piston valve, which is suitably constructed to remain steam tight, runs in bronze valve chambers having gridiron openings the entire circumference of the valve, thus insuring very quick admission and ample steam opening with the minimum of valve travel. Admission ports are at the end of the valve and the exhaust in the center, insuring the desirable feature of short and free release. By the use of the rocker arm, the eccentric rods can be made somewhat shorter than in the ordinary engines of this class. Both connecting rods and eccentric rods are of hollow steel, with solid forged ends. The eccentric rods have strap and key joints, with brass boxes at each end, and connect with steel cranks on the ends of the paddle wheel shaft. These cranks are usually set quartering, so there is no dead center, and the engines move either ahead or astern, according to the position of the link, instantly when the throttle valve is opened. Several river boats so fitted are now under construction at the shops of Charles P. Willard & Co., 15 North Canal street, Chicago.

Eaves Helical Induced Draft.

An improved form of induced draft applicable to Scotch boilers on sea or land, in conjunction with Serve ribbed tubes, is shown in the accompanying illustration. The cold air for the combustion of the fuel enters from the back end of the boiler, passing along the outer space A and A′ to the valves B and B′ in furnace fronts as shown in the cut. On its way the cold air is guided around the outside of the "inner" space C in a "helical" or spiral direction by the partitions shown. After combustion, the waste hot gases discharged from the tubes pass through the smoke-box into the inner space C, and by partitions are also made to pass around and in close contact with the boiler, in a "helical" direction, on their way to the suction fan. It will thus be seen that the boiler is completely enveloped in the waste heat, which would otherwise pass into the smokestack or chimney unused, and that both "radiation" and "condensation" are effectually prevented. It also prevents any straining of the boiler under forced conditions, such as the rapid generation of steam from cold water, or sudden and greatly increased evaporation. The

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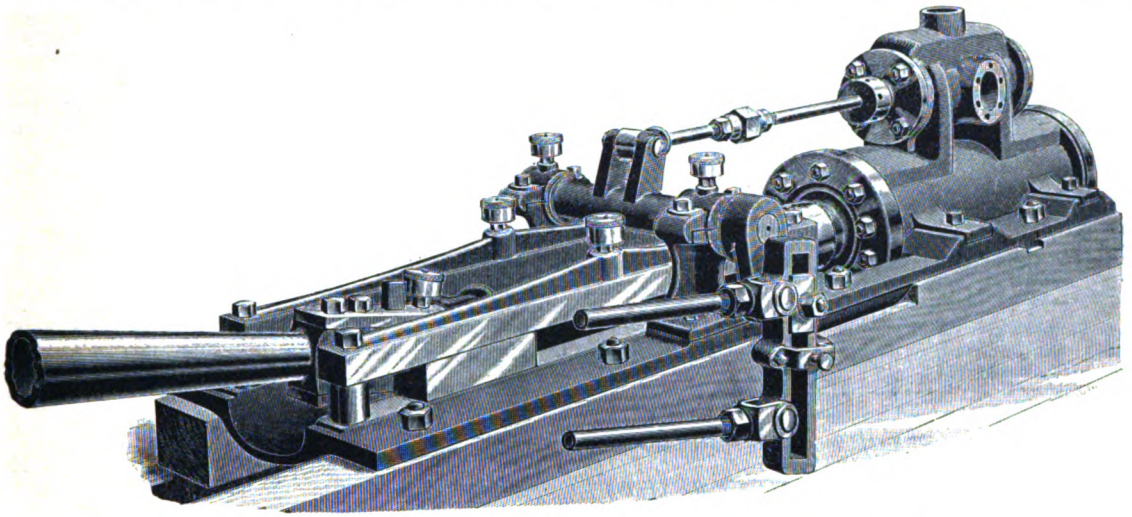
cold air, too, on its way to the valves B and B' absorbs much heat from the waste gases and enters the furnaces at a high temperature. After making careful tests, John Brown & Co. (Ltd.), Sheffield, Eng., state that a very high efficiency

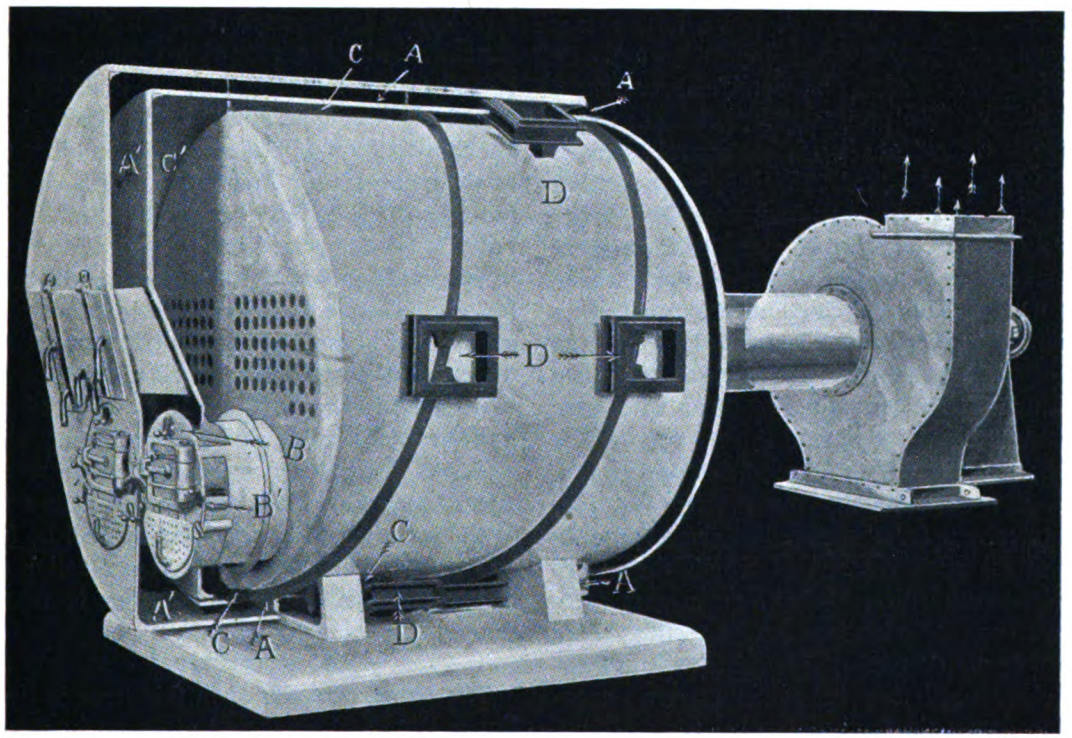
bustion of over 30 lbs. of coal per sq. ft. of grate, and with a ratio of heating surface to grate surface of only 28 to 1. It is claimed that two boilers with natural draft would be required to do the work of one of the same size fitted with the



WILLARD BALANCED PISTON VALVE ENGINE FOR STERN WHEEL STEAMERS.

is obtained by the use of this draft. Tests made with boilers fitted with Serve ribbed tubes,

Helical Draft and Serve tubes, and as space is worth something on board ship—to say noth-



EAVES HELICAL INDUCED DRAFT FITTED TO SCOTCH MARINE BOILER.

showed an efficiency equal to 80 per cent of the actual calorific value of the coal used. With Welsh coal, which has a calorific value of 16.18 lbs., the evaporation was 13 lbs. of water per lb. of coal, from and at 212° F., with a rate of com-

ing of the economy in fuel—an investigation of the claims for this new system of draft would seem to be a profitable field for investigation by engineers and steamship owners. The agent is Charles W. Whitney, 11 Broadway, New York.

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The fifth general meeting of the Society of Naval Architects and Marine Engineers, held during November, was a successful and representative convention of the constructive marine interests of the country. A good programme had been arranged, and the papers as a whole were of special interest and were fresh evidences of the ability of the profession in America, which only needs the aid of speculative capital to make this the foremost shipbuilding and ship-owning country in the world. Indeed, the high standard and special character of many of the papers read made some discussions seem, by comparison, rather weak. This was due entirely to a feature of the arrangements and not to any lack of capability of those present to add accurate criticism or helpful suggestion. Few of those who were in attendance had had much, if any, opportunity previous to the meeting to read the papers presented, and consequently many were not prepared to take a forceful part in debate, or even speak at all upon matters in which they were recognized authorities. It is an experience common to all scientific bodies that, frequently, those who are best informed on a subject will not express views until they have had proper opportunity to digest the facts presented for criticism. The more able the paper read the greater the need for quiet consideration of its expression in the light of one's own experience. This applies especially to a body, such as the Society of Naval Architects and Marine Engineers, whose membership does not include a large proportion of sea lawyers or parliamentarians, skilled in ready debate. The habit of mind of the Naval Architect and Engineer is essentially reflective, trained to careful consideration of cause and effect. Action rather than elocution is the physical result. But even supposing that the papers read were of an every-day character, about which intelligent judgment would be in the ready possession of the hearers, the fact that they were read at the meeting would not have altered the results. Many of the members in attendance had occasion to transact business elsewhere at times during the sessions and would perhaps arrive in the hall in time to hear only a portion of a paper, treating of a subject with which they were familiar, and by hearing part, and not the whole, would get a wrong impression of the author's views. The result could only be confusion. We have spoken of this matter at some length because we believe that an outsider, reading the transactions, would possibly get a wrong impression of the information and authority of the society, in the light of its discussions. Another source of distraction from the purposes of the daily technical sessions was the necessity for members who, perhaps, came together only at the annual meeting, renewing their acquaintanceships in the convention hall. It is difficult to intelligently follow an author and keep up a pleasant conversation with a neighbor, on other topics, at the same time. Members do not come to a meeting solely to hear papers read and discussed, but also for the very desirable purpose of getting in personal touch with their brethren of the profession. This experience has caused similiar societies at home and abroad to set apart a time during the convention in which the members may meet and fraternize. It is regrettable that more representatives of the operating departments of the mechanisms discussed were not in attendance. On other pages in this issue a report of the proceedings at the meeting will be found; also a commencement of the reproduction of papers read, which we shall continue in future issues.

The paper reproduced in this issue is by Professor W. F. Durand and gives an introductory account of an investigation into the influence of surface on the performance of the screw propeller. Of the many features which may enter into this problem all are kept constant except *pitch ratio*, *slip*, and *surface ratio*. The investigation is intended to proceed with an ac-

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companying variation of these features, each in turn, the others meanwhile remaining constant at various values within a wide working range. Such an investigation, even partially completed, is worth far more than an equal amount of desultory work. The use which can be made of such data as are presented in the paper will depend much on the individual. It seems to be the intention of the author to provide certain definite scientific data showing under certain circumstances what may be expected. The engineer is left free in the exercise of his judgment, as to how nearly these circumstances represent those with which he has to deal. The portion of the proposed investigation which is here reproduced relates only to pitch-ratio, or probably one-fifth of the whole. We believe we voice the wish of the entire profession of marine engineers and constructors in expressing the hope that the author may be able to complete the experiments.

Differences which have existed between the Line and Staff Corps of the Navy for many years are now the subject of inquiry by a special board of naval officers, with Assistant Secretary of the Navy Theodore Roosevelt as president. The membership of this board includes:

Captains W. T. Sampson, A. S. Crowninshield, Robley B. Evans, and A. H. McCormick; Commander J. N. Hemphill, Lieutenant Commander Richard Wainright, and Lieutenant A. L Key, on the part of the Line, and Engineer-in-Chief G. W. Melville, Chief Engineers C. W. Rae and G. W. Kearney, and Passed Assistant Engineer W. M. McFarland, of the Engineer Corps.

At this time the result of the deliberations of the committee is a scheme to amalgamate the two corps—carried by a vote of 9 to 1. So far as known the scheme contemplates assigning only engineering duty to the senior thirty-six engineers now on the navy list who hold the relative rank of captain, commander, and lieutenant commander. Engineers of the relative rank of lieutenant may qualify for line duties if they so elect, or, in case they do not, they are to be eligible only for duty in connection with the machinery. All other grades of the Engineer Corps are to be absorbed by the Line, and these officers must qualify for line duties. To put it plainly the identity of the Engineer Corps is to be destroyed. The only possible explanation for this proposed Gilbertian combination is that it is a compromise. Parenthetically it might be asked, why not carry the plan to its logical conclusion? Amalgamate the scriptural and surgical departments, so that the surgeon-chaplain may minister to the needs of body and soul simultaneously or alternately. Also join the Naval Constructors and the Pay Department in the bonds of unity and peace, and do likewise with the Marine Corps and Civil Engineers. In this age of specialization the scheme proposed is extraordinary. We wonder what the directors of the American line would reply to such a proposition for the reorganization of their forces. It would likely be brief and expressive. Certainly the proposal is not in accord with the suggestions of Engineer-in-Chief George W. Melville, who, in his annual report, states "two things are necessary to the highest efficiency of the Engineer Corps." These are, an increase of numbers from 195 officers to 300, and the conferring of actual rank and titles. The first is a reasonable, even modest request, clearly in the best interests of the Navy, and so of the nation. As to rank, that is one thing, title another. That an engineer of the Navy should stand squarely on his rights, and that these should be absolute in his own department and co-equal with those of his brother officers in other departments, where, owing to the exigencies of the service his authority might be needed, is a proposition that only prejudice, ignorance, or vested interests could dispute. That his title should be other than "Engineer," with such additions as would signify his actual rank or length of service—as now in force—we cannot perceive. The name Engineer is more misused than any other signifying a man of brains, but nevertheless it is a grand title, the noblest of the century. Other naval titles, from Admiral down, have been hallowed by age and made glorious by memories, but future battles will not be fought by heroes of the past. The modern ship is truly an engine of war, and what better name could designate the officer who should keep this in efficient condition than Engineer? But a ship has to be navigated and the guns operated to be effective in war. Do the line officers admit that these duties are so relatively unimportant that they will have ample time to properly administer the duties of the engineer officer as well? Considering the ever increasing importance of the mechanical equipment of the war vessel, possibly this position is well taken. For our part we do not so believe. The real engineer is born not made, though it is only in the merchant marine that the survival of the fittest is really worked out. The sailor and engineer, as such, have little in common in their makeup, and though the former needs be a fighter, the latter may be peacefully efficient, though none the less courageous.

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PROCEEDINGS AT THE FIFTH GENERAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

HELD IN NEW YORK, NOVEMBER 11 AND 12, 1897.

Concise Report of Routine Business, Which Included Passing of Resolutions, Election of Officers and of New Members.—Brief Abstracts of Papers Read and Gist of the Discussions Which Followed.

At the engineering headquarters, 12 West Thirty-first street, New York, the fifth general meeting of the Society of Naval Architects and Marine Engineers was held on November 11 and 12. There was a good attendance of members, though many familiar faces were not in the hall when, in the unavoidable absence of President Clement A. Griescom, Charles H. Cramp called the opening session to order. He explained the circumstances, and called John C. Kafer, member of the Council, to the chair. This was a happy choice, for throughout the proceedings he performed his duties with dignity and great courtesy.

Charles H. Cramp was given the floor to present a set of resolutions. He said: "Last summer our society was honored with an invitation from the Institution of Naval Architects to join in the International Congress of Naval Architects and Marine Engineers to celebrate the Queen's Jubilee. The Congress lasted from July 5 to 15 of this year, the meetings for the discussions of papers being held in London, and the excursion, including visits to Portsmouth Dockyard, Southampton, Glasgow, and Newcastle. In addition to this the many social features of the Congress included a visit to Windsor and a reception by the Queen. Our transatlantic cousins were most cordial hosts, and it seemed to us that our common speech and ancestry made our welcome the warmest. All of the arrangements were perfect, and the whole elaborate programme was carried through with great success. Our society was represented by a fair number of members, including two former Engineers-in-Chief of the Navy, several of our leading shipbuilders, and two delegates sent by the Navy Department. Besides the entertainments on the programme, the individual members of our delegation were the recipients of many personal courtesies. To show our personal appreciation of the kindness we had experienced, we sent an engrossed testimonial to the Institution of Naval Architects before we separated in London. It seems to me, however, that it would be a graceful act for our society to do something in the way of placing on record its appreciation of the courtesies shown to its representatives, and I have the pleasure, therefore, to offer the following resolutions:"

Whereas: The British Institution of Naval Architects on the occasion of the Diamond Jubilee of the Queen's Reign invited this Society to join with it and like organizations of other countries in an International Congress of Naval Architects and Marine Engineers, and

Whereas: The possibilities of hospitality and courtesy were exhausted by the British Institution toward the representatives of this and other like organizations elsewhere who were its guests.

Therefore Resolved, That the American Society of Naval Architects and Marine Engineers do offer the British Institution this expression of its profound sense of the courtesy extended and of the hospitality lavished, and,

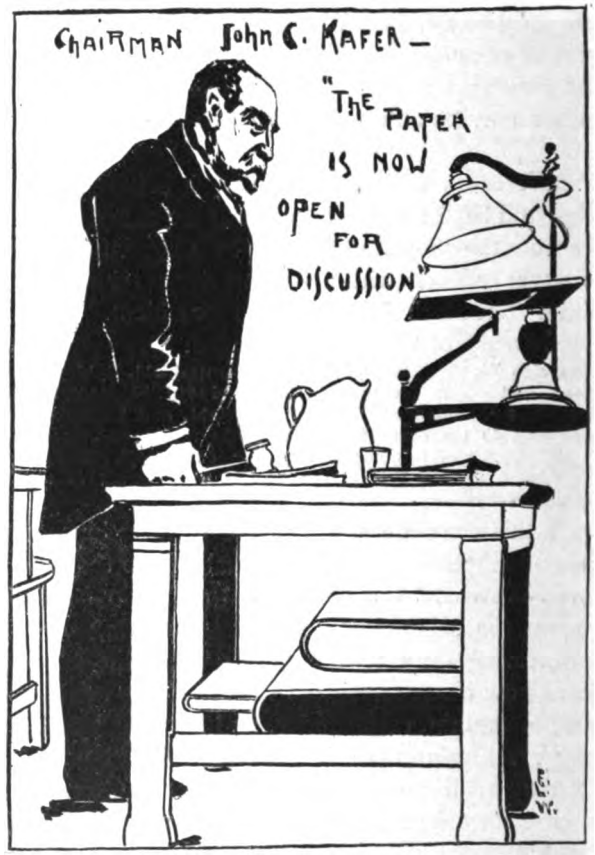
Resolved, That a suitably engrossed copy hereof be sent by this Society to the British Institution through its President, the Earl of Hopetoun.

E. Platt Stratton seconded the motion.

Chairman Kafer spoke briefly. He believed it was right that the society should take cognizance of the treatment received by members, and others who were not members, at the recent meetings of the Institution of Naval Architects. "I think it eminently proper that we should pass a resolution of this character because we cannot do too much to honor the Institution which is the parent of ours."

Charles Ward, who had attended the British meetings, said the entertainments provided for visitors were simply superlative. He did not believe the society could express itself in any way too strongly in appreciation of the kindness shown to the American visitors. The motion was unanimously carried and ordered engrossed.

Secretary Francis T. Bowles read the report of the council, and election of members was taken up. These were unanimously elected:



Members—Carl Herbert Clark, Robert Brooke, Henry Hess, Everett M. Mathews, William Poultney Smith, Harry A. Spiller, Alexander Thomson, Nathan Pratt Towne, Fairfax Williams, and Siegfried Popper, Hungarian Navy, and C. Ferrand, French Navy.

Associate members—John W. Burnham, Mason Smith Chase, Winthrop Cole, William Henry Deming, John F. Kane, Parker Henry Kemble, Thomas S. Mathewson, Axel Samuel Vogt, Spencer Miller, and Frank Richard Wheater.

Juniors—Joseph Ward Clary, Ralph Worthington Crosby, Max Dercum, Henry Newton Whittelsey, Morris Mortimer Whitaker, Herold Lee, and Henry A. Swanton.

James Swan was promoted from Junior to Member.

Chairman Kafer referred feelingly to the death of

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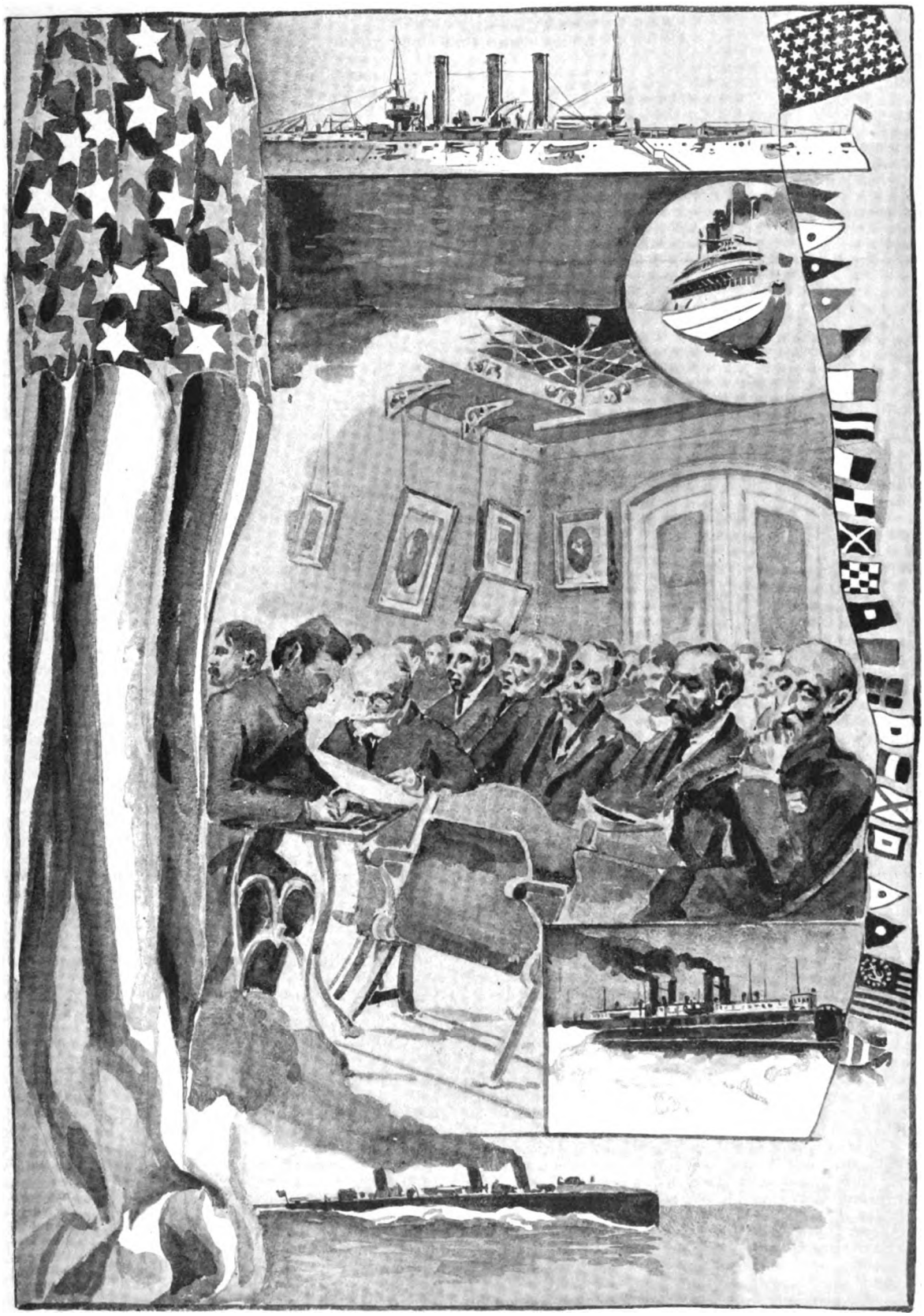

SCENE IN AUDITORIUM DURING THE FIFTH GENERAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

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Vice-President Rear Admiral Richard W. Mead, which had occurred during the year.

Captain Miller presented resolutions in which the society expressed its appreciation of the "chivalrous character and knightly loyalty" of the deceased naval officer, and these were adopted by a standing silent vote.

Nominations of officers resulted in the re-election of the entire list of officers, with the additions to Vice-presidents of Commodore F. M. Bunce, U. S. N., to fill the vacancy caused by the death of Admiral Mead, and General T. W. Hyde, to fill the vacancy occurring during the year, and Colonel E. A. Stevens, additional. Members of the Council elected were: Passed Assistant Engineer W. M. McFarland, U. S. N., and Professor C. H. Peabody. This for the time concluded the routine business before the meeting, and attention was next given to the technical papers.

WATER TIGHT BULKHEAD DOOR.

The reading of papers was begun with that of William B. Cowles on "Water-Tight Bulkhead Doors and the 'Long Arm' System on the U. S. S. Chicago." This describes a system of closing doors by hydraulic power, the term "long arm" being applied as descriptive of the method of controlling the position of all doors from a central station by an operator, who is thus enabled to "reach out" in any direction throughout the ship. Instead of requiring nearly 100 men to close doors, as in the case of the battleship Massachusetts, one operator in the central station can make all compartments tight. A modification of this system is also described in which the closing of doors would ordinarily be effected at their respective locations, but in cases of emergency the officer in charge of the ship can close all doors simultaneously. In both systems an attachment at each door permits the opening of the door by any person shut in a compartment by reason of an unexpected closing of the door. This automatically causes the door to close again after the person is released. The doors on the Chicago are of the vertical sliding pattern connected by a piston with the hydraulic power cylinder.

Naval Constructor Francis T. Bowles, U. S. N., in opening the discussion, said in considering the fittings of warships he was opposed to further complexity and rather advocated simplicity. After careful consideration, however, he had recommended the introduction of the Cowles system on the Chicago in its simpler form. The great advantage of the door seemed to be that the application of the water tightness did not occur until the door was in position and seated. The reverse process was followed in opening. He was not in favor of a central system for operating doors by calling up an operator, who might not be on hand when most needed.

Lieutenant William P. White, U. S. N., also advocated simplicity, but at the same time some positive-acting apparatus was needed for closing doors. The confusion following the signal to close doors on a warship caused unavoidable delay. Under present methods there was the possibility that openings in coal bunkers in protective decks might be left open, and there was no means of examination except by opening the doors communicating with the fire rooms. It was a common occurrence to have five or six men operating a screw on the berth deck to close a door and, even with the aid of some convenient lever, being unable to get the door water tight. He considered the inventor deserved the thanks of all men who go to sea.

Lewis Nixon spoke in favor of the system, which he said was absolutely certain in its application, for even in action if some of the supply arrangements were shot away it would still be possible to go to each door and close it by the pump attachment.

Colonel Edwin A. Stevens wanted to know what the effects of shell fire would be upon the system; if local damage to one of the pipes would affect the system, and in such a case if it were possible to arrange the gear so that all the doors would close, much as the air brake valve applies the brakes on a train in case of damage to pipes. He had had experience with collisions in smooth water and had observed that anything near the point of impact was much distorted, water and steam pipes almost invariably leaking badly. These collisions occurred between light vessels at low speeds and the energy of the blow was not comparable to that delivered in the case of H. M. S. Victoria, or the S.S. Elbe. He supposed every one knew the valuelessness of any present device for closing doors, and recalled cases where water pressure had got on one side of a bulkhead where there were openings, and leaks invariably followed.

Mr. Newman said the system was really simpler than present methods. He cited instances in his experience abroad, in one of which it required several men to close the bunker doors in a light-armored cruiser. In another case of a 5,000 ton armored cruiser similar results were experienced. Very stiff door frames were a necessity. When running only from one dockyard to another, in a ship in which the doors had been accurately fitted, on arrival at the second dockyard it was found impossible to close the doors. He believed the Cowles system would find its most important application on transatlantic liners.

Charles H. Cramp spoke briefly. Complexity on a ship was to be avoided. Each individual system placed on board a ship, such as electricity, drainage, ventilation, the handling of ammunition, the movement of turrets, and others, was now much divided, so that the ship had grown to be such a monster that it could not be managed by one man. He believed the modern ship too complex. The greatest ship building establishment in the world employed an expert, at a large salary, to make daily walks through every ship building and find out, not what could be added to the ship, but what could be dispensed with.

A. F. Yarrow, the English torpedo boat builder, who was present, was called on by the chair, and replied that he knew nothing about water-tight doors. "In all the boats we build," he said, "we do not adopt water-tight doors at all."

E. Platt Stratton called attention to the subdivision of transatlantic liners into anywhere from ten to sixteen compartments with water-tight bulkheads. It was desirable to employ men in certain compartments and have their duties confined to such compartments, so as to obviate as much as possible the necessity for men moving from one part of the ship to another in case of emergency. This also did away with the necessity for a number of compartment doors. The method might possibly be applied to naval vessels.

Mr. Coles in closing the discussion argued that the present multiplicity of shafting and gear, connecting doors with the closing mechanism on the berth deck, was not only unscientiuc and bad engineering, but more complicated than his system. By the adoption of the central station plan in battleships, for instance, instead of requiring 110 men to close the swinging doors, three or four at the most could make the entire ship secure. The others would be available for other emergency duties, such as getting out the collision mat. Regarding the effect of shell explosions on piping and the system, in the Chicago all the system was placed below the protective deck with the exception of the 1-8 in. pipes operating the valves and telltale in the pilot

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house. She had no protective tube under the conning tower, and consequently these pipes were exposed to gun fire. In such a case an automatic cut-off valve would keep the system below deck intact, and this was applicable to any exposed branch. The jar and strain of gun fire or shell explosions affected large pipes, which are stiff and have great inertia, more than small pipes which take up motion quickly and and are more flexible. In the Chicago the largest diameter of pipe was but 2 in. and this ran for only a short distance. In case of damage to the system the doors could be worked by hand, the discharge from the power cylinder running to a reservoir which always remained full, giving sufficient capacity for the operation of the hand pump, which could be worked more quickly than the present locking devices. A door on the Chicago was pumped up by one man in ten seconds. It was simply a question of piping and areas, and capacity of pumps.

REGULATIONS FOR LOADING VESSELS.

"Regulations for Loading Vessels" was the title of the next paper, read by Lewis Nixon. This consisted of a statement of the rules and regulations of the British Board of Trade, and the American National Board of Marine Underwriters, governing the loading of vessels. The author also stated that the loading of steamers in American ports is practically in the hands of the underwriters, though their business is not so much in the direction of proper stowage as in adjusting the rates to the character of risks run. The government should strengthen their hands in every way possible without interfering with trade, and this could only be done through a body similar to the British Board of Trade. The effort of this government has been more in the direction of providing safeguards against loss of life and against boiler explosions.

Chairman John F. Kafer said the rate of insurance usual in any commercial enterprise would govern such matters. If dealt with by legislative action it should be carefully handled so that it might not be overdone.

E. Platt Stratton said any interference of the government with the private affairs of merchant shipping would have to be done discreetly. The steamboat inspection service was now carried out in a pretty efficient manner, but how far this might be extended in the line of a general shipping act he was not prepared to say. He advocated caution.

Mr. Newman, speaking on behalf of the shipping of the Great Lakes, said during his stay there he had noticed with great astonishment the careless methods adopted in the manner of sending ships out of port. He had seen ships carrying from 4,000 to 5,000 tons coming down from Lake Superior to Lake Erie, and he thought he might safely say they had no more than 4 inches of freeboard. This was entirely improper and should be made criminal. The argument he had found used was that they never had very serious accidents, but at the same time accidents did occur. It seemed that it would be proper to draw up a code of laws governing these methods of loading, and he styled Mr. Nixon "the American Plimsoll."

E. Platt Stratton said that about five years ago a bill was presented to Congress to regulate the matter of freeboard, especially on the lakes; but it was discovered that there was not water enough in most of the channels to load vessels down to the proper line of freeboard, so the whole matter was dropped.

Mr. Nixon, in closing, said the bill fathered some years ago by Senator Fry was too complicated and would have been an interference with trade, so it died a natural death. There was a dangerous liberty allowed in loading ships along the coasts and some restriction should be placed on it.

TORPEDO BOAT DESIGN.

The paper on "Torpedo Boat Design" was read by the author, Assistant Naval Constructor H. G. Gillmor, U. S. N. He gave a concise history of the torpedo-boat in general and the U. S. torpedo-boats in particular, from the torpedo-launch Lightning of 1876 to the latest destroyers. This was followed by a dissertation on the functions of the torpedo-boat and a practical consideration of the question of design under the two heads, viz: The seagoing boat and the harbor or coast defense boat. The paper was accompanied by carefully drawn sketch-plans for both types of boat and tables of dimensions and other data. The special features of design included the use of single screws with, of course, one set of engines. The estimated cost of the seagoing boat was given as $100,000, and of the harbor boat, $30,000.

Assistant Naval Constructor Frank B. Zahm, U. S. N., said of the list of twenty-one boats given by the author probably eighteen would be in active service in another year. The most interesting in the list were the six thirty-knot boats, for which, in the matter of proposals and bids, the bidders had been given every possible latitude in design. With regard to the three boats for which bids were received last June, it was observed in examining the designs that three types were represented, the Thornycroft, the Yarrow, and the Normand. There was little originality shown in any of the designs. It was the desire of the chief constructor that the boats should be distributed between the three types, but because of incompleteness and price the bid on the Yarrow type was thrown out on the final settlement. The chair called on Mr. Yarrow to speak, and the renowned English builder was received with applause when he arose.

Mr. Yarrow proposed a vote of thanks to the author of the paper, which, he said, on its face evidenced a great deal of work and research. As Yarrow boats were referred to in the paper he would give some account of the performances of boats mentioned. The Entre Rios, a torpedo-boat destroyer built for the Argentine government, ran from St. Vincent to Buenos Ayres, a distance of 3,700 knots, on 130 tons of coal. This was 28 knots to the ton. In running this and three similar boats a gain of about 5 per cent in economy was secured by working one engine and one screw and disconnecting the other. The speed on the run out averaged 9 knots and the mean load carried was 80 tons. These boats had thicker plates and were consequently heavier in displacement than the ordinary torpedo-boat destroyer. The Injeniero Hyatt, built for Chili, ran to Los Palmas in five days at 12 1-2 knots an hour on a consumption of one ton for 60 knots. The entire run out of 11,000 miles was made with 185 tons of coal and 135 gallons of oil. Two days after the arrival in port, and without cleaning the boilers or making any preparations, the Chilian boat ran her official trial trip successfully. "I think one point that is worthy of the consideration of naval authorities," he continued, "is whether any steps should be taken to offer some protection to the machinery of the torpedo-boat or torpedo-boat destroyer from rifle fire or small shot, or shots that hit at a very fine angle. I imagine that it would be a very difficult thing to find any part of the boiler or engine room that could be pierced with a rifle shot without its hitting something that might possibly disable the boat, and therefore I think that it is not unreasonable to suppose that some reduction of speed might be worth being exchanged for some protection. As to the Kotaka, referred to in the pa-

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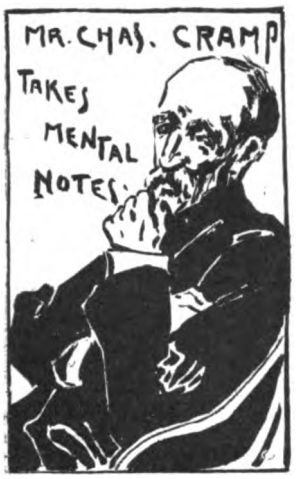

per, that is a Japanese torpedo-boat which we built about ten years ago. The deck and the sides where the engine room and boiler room were, were protected by 1 in. plates, and this boat led the torpedo attacks, the two principal attacks that were made by the Japanese, one at Port Arthur, and the other at Wei-he-Wei, and there was a great gain by this protection. Of course an inch plate will do a good deal against anything like small arms. In the boats that we built for the British government for the Nile (there are eight of them), we used hard steel plates 3-16 in. thick, and they were proof against the Lee-Metford rifle at point blank at 20 yards. Suppose these plates were suitable for torpedo-boat construction and were increased to 1-2 in., with the reduction of speed for that increased thickness below what it otherwise might be, we will say half a knot, or further increasing the thickness at a sacrifice of a knot, it appears to me that it might be worth paying that price for. It is a matter for very serious consideration of naval authorities, I think, whether something of that kind should not be done. Of course in any construction like a torpedo-boat we have got to take a great deal of care that we do not have a rigid portion of the vessel and join it to a very elastic portion, suddenly. Whatever change in the elasticity takes place must take place very gradually. As regards the coal consumption, it may, perhaps, be interesting to know that between the locomotive boiler and the water-tube boiler there is a decided gain in favor of the water-tube boiler under the same conditions of trial. We have tried this very carefully, and that gain varies from 7 to 10 per cent in favor of the water-tube boiler. The author refers to the Russian torpedo-boats. He says that 100 boats were built by the Russian government very early in the torpedo-boat constructing age, and that they were built by different firms. They were all built by the Baltic Works, at St. Petersburg, of which Captain Casey was the head, and a very distinguished man he was. I suppose you are aware that the French on their trials use briquettes, and there is no doubt a very great gain by using the briquettes over any Welsh coal. These briquettes are made out of Welsh coal. The coal is washed very carefully and then amalgamated together. We have found when we have had a difficulty in getting a trial through with some Welsh coal, if we sent over for some French briquettes we very often got through without difficulty. The great advantage briquettes give for a trial is that there is no cleaning. This fuel is very uniform in its character and is made by the French government particularly for torpedo-boat work. There is one thing that you will find a difficulty in, and that is arriving at any comparison between torpedo-boat trials of different nations and different constructors. If one could only get everybody to agree to a certain standard of trial it would simplify matters very much in tabulating results. Of course the French trials have a great advantage in consequence of the use of these briquettes, and the English government will not allow us to use briquettes. In reference to any increase of speed, you will all agree with me that when increase of speed is only obtained by increase of size there is no very special credit in consequence, and I should like in touching on this part of the subject to refer to my friend, M. Normand, who is a very distinguished man, and a scientific man of a very high order. He has been particularly successful in obtaining speeds on small dimensions, and that is where the real credit in construction lies. A gentleman was referring to the speed of some of these destroyers, and of course I take it that the government has a certain amount of money to spend on vessels of this class, and it is a matter for consideration how they should get the greatest amount of defence or offence for a given sum. You will find that the difference between 27 knots and 30 knots means an increase of price of 50 per cent. Now, it does appear to me that, in many countries, it is extremely questionable whether the additional three knots is worth paying so much for, considering that you could get three 27 knot boats for what two 30 knot boats would cost."

Lieutenant William P. White, U. S. N., said a torpedo-boat when approaching a vessel or fleet would be compelled to reduce speed so the wave caused by the screw and bow would not be perceptible, and discover the position of the boat. Thirty knots was entirely in excess of requirements, except in the case of destroyers.

Mr. Wheeler asked Mr. Yarrow what advantages briquettes had over coal.

Mr. Yarrow: "I do not know if for a given quantity of coal or briquette we get any more speed. The briquette is much easier to handle and does not clinker over the bars. That is principally where the gain is."

Mr. Swan inquired whether the "good economy gained in some of the French boats was due to the use of briquettes?"

Mr. Yarrow replied: "I am not aware that there is any more economy in the French boats than the English ones."

Mr. Swan: "As I remember the results, they certainly show a very unusual economy per horse power per pound of coal, and I thought perhaps it was due to that. It would be rather hard to weigh the briquettes and balance that weight against the weight of coal."

Mr. Yarrow remarked that he supposed they were "published" accounts, with an accent on the "published," and Mr. Swan responded that "they were."

C. D. Mosher said the matter of speed was often misjudged. The speed of a torpedo-boat on its official trial very much exceeded that which would be realized in practice with an ordinary crew. Thirty knots was not too high speed for a boat which had to keep out of the way of our fastest cruisers, in case the water was rough. If a reduction in speed due to the inefffifficiency of the crew and rough water were made it was a question whether or not a 30 knot boat, that did not exceed 200 ft. in length, could retain a speed of more than 23 knots in reasonably rough water. A 26 knot boat would not meet the requirements at all in practice. Recent experience everywhere had been to increase speed due to size largely, but much could be done on a smaller boat in the matter of speed. "We have only made a beginning as to the speed at which we can run the engines satisfactorily, and the number of cylinders used," he said. "I think economy can be carried very much further, beyond what has been done. Economy at the engines is of the greatest importance, for it reacts back on the size of the boilers and the coal consumed, not only for a short period of time, but throughout the entire mileage of the boat. If worked out, it will be found, perhaps, that an economy of 5 per cent in the engines may amount to 15 or 20 per cent increase of mileage of the boat." As to obtaining high speeds with small boats there was likely to be more progress in these than in larger boats. Few would experiment with large boats; but in the case of small yachts and launches things could be carried to an extreme that would not be attempted from a purely commercial standpoint. As to "fatigue" there was evidence, from the experience of eminent build-

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ers in the reduction of vibration and other features of fatigue, which completely changed ideas that prevailed before these questions were gone into. By giving attention to vibration, taking care in the counterbalancing of the engines and distribution of weights, certain portions of the boat could be put under tension, or expressed differantly, it would be possible to change the tune of the boat and reduce vibration very much. Not much had been done in this direction, though if investigation were carried far enough the evils of fatigue could be so reduced as to be an unimportant factor on very long runs at high speed. On high-powered boats which the speaker had recently constructed, vibration was so reduced that, except at the critical points, it was not noticeable by any tests, such as filling a glass to the brim with water.

Thursday Afternoon, November 11.

Chairman John C. Kafer called the meeting to order at 3:10 o'clock in the afternoon and announced further discussion on Mr. Gillmor's paper in order.

Professor W. F. Durand referred to the absence of data regarding "Power" in the paper. This was not the fault of the author, for such data was not obtainable. In order to obtain the best results it was necessary in designing to have comprehensive data covering the particular classes of vessels dealt with and drawn from vessels working under generally similar conditions. The step from data relating to Atlantic liners to the design of torpedo-boats could not be made, and data covering the torpedo-boat itself was absolutely necessary. There were great practical difficulties in the way of securing diagrams from these fast running engines, and contractors did not as a rule desire the encumbrance of persons taking cards on official trials. He desired, however, to call special attention to the lack of such data, and believed it would be well worth while for the government to obtain data regarding power subsequent to the official trials. The revolutions and general characteristics of the propellers were usually obtainable, but no judgment could be formed regarding the propulsive and general economic performances, without the important item of indicated horse power.

Chairman John C. Kafer had no doubt, should an emergency arise, harbor tugs would be equipped with torpedoes—a dozen of them—to attack any possible enemy. It would not make any difference if eleven of them went down, men enough could be found to do the work if the honor and emolument were made large enough. This was the experience during the civil war.

Mr. Gillmor in closing the discussion said, with regard to the warning of the coming of torpedo-boats on a ship, there was little experience from which to draw conclusions. In the case of the Ting Yuen timely warning was given by the pickets, but the boat which sunk the war vessel was within less than half a mile when she was discovered. He agreed with Mr. Yarrow as to the advisability of protection, but it was a matter for those who used the boats to decide whether it was worth the necessary sacrifice. The value of trained crews was shown in the performances of U. S. boat No. 6. Great difficulty was experienced in running with a crew composed of men from the builders' works, but after some of the crew of the Cushing assisted, a satisfactory official trial was possible. A torpedo-boat which on trial made 25 knots should be fully capable of repeating the performance with such a crew as she would have after being for a time in commission. He agreed with Professor Durand as to the necessity for power data, and in the absence of this, he had incorporated such data regarding machinery in his paper as make possible an approximation to results.

PAPERS READ BY TITLE.

In the absence of the authors two papers were next read by title. These were: "The Commerce of the Great Lakes," by Charles E. Wheeler, and "Progressive Speed Trials of the Boston Police Boat Guardian," by Professor Cecil H. Peabody.

INFLUENCE OF SURFACE ON SCREW PROPELLERS.

Professor W. F. Durand then read his paper on "An Experimental Study of the Influences of Surface on the Performance of Screw Propellers." This will be found in full, with the accompanying drawings, elsewhere in this issue. The discussion following the reading of this paper was along practical lines rather than an expression of critical opinion of the scientific investigations pursued by the author.

Chairman John C. Kafer said as to the propeller there was no one thing about a ship so little understood, but about which people thought they knew more. In making a propeller one particular to be borne in mind was not to have the propeller travel slower than the ship itself. "I always considered that the bow of a ship was resistance enough," he said, "but I have found a great many propellers where part of the propeller blade traveled at a very much less speed than the ship itself. This is due to the thickness of blade. While the driving surface of the blade would have ten, fifteen, or twenty per cent more pitch than due to the speed of the ship, the back of the blade had often much less pitch, so I have made many alterations in propellers. By altering the pitch near the hub, I made the back of the blade the same pitch as the speed that the ship was designed for so that it would travel along with the speed of the ship and have a beneficial influence." He then referred to the influence of surface, citing the case of the U. S. SS. Marblehead, Detroit, and Montgomery, which were identical in build. The engines of the Marblehead were built with great care and were expected to give more power than the others. There was a premium on speed, and the propeller for the Marblehead was given a little more surface than that for the Detroit. The result was remarkable, as with the same power they could not get the same speed, and a substantial loss of bonus money was the result. This was entirely due to increase of surface, for the Marblehead was a better boat under ordinary circumstances. On trial the other vessels got more speed with less power. Calling attention to Professor Durand's method of measuring thrust, he said, Mr. Mattice when in the Navy designed a loose thrust block with a hydraulic balance so that an indicated thrust could be got at all times when the ship was under way. It would be a desirable addition to all vessels of the navy. He then referred to recent experiences connected with the construction of three merchant steamers by his firm. These were the Yorktown, Jamestown, and Princess Anne, of the Old Dominion line. The latter had 250 tons more displacement and 2 ft. more beam and yet required less power and less coal per trip by about 7 to 8 per cent. The real cause of this had not been discovered, but he believed it was attributable to wave formation. The propellers were identical, so that comparisons of ships of almost the same size, with similar or different propellers, were not entirely reliable in determining which was the better propeller. He said Mr. Yarrow's plan was to make five or six propellers for each boat and try the one thought to be best suited. If the speed was got with the first propeller the others were discarded.

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Dr. Charles E. Emery: "A boat built, say, in Philadelphia, will come to New York, and a man after watching her will agree to do much better by putting on a new propeller for so much money, and will probably do it. The power which is developed by the machinery has a great deal to do with it, and the changes in speed may be due simply to the fact that the boiler steams more freely and the engines can make a few more turns. It has nothing more to do with the propeller and yet it has much to do with the particular boat. Or if the boiler does not steam freely a little more pitch relieves the boiler; they do not have to fire as hard and the boat does better—less coal is wasted and the boat is more efficient."

Mr. Newman was of opinion that the distribution of surface was a very important factor in propeller problems and cited the trials of the British war ship "Iris."

F. L. Du Bosque said the amount of work done by the author was enormous and he deserved the encouragement of the society in conducting his research.

H. B. Roelker had also seen boats come here from Philadelphia which had shown good speed with narrow blade propellers. Here, however, they were too slow for practical service because they could not be handled quickly. They were boats built for making many river landings and it was found necessary to nearly double the width of blade. An uncouth looking propeller was the result, but the time between points was reduced by about an hour and a half, as stopping and starting at landings was more quickly done. Old river men were apt to insist on very wide blade propellers for just these reasons. Narrow blade propellers gave very high efficiency, and where it was possible to choose diameter a two bladed very narrow propeller gave greatest efficiency.

Professor Durand in closing said his purpose had been simply to ascertain certain facts, and he hoped that the data here presented, with more of a similar character which he hoped to be able to derive in the future, would be of aid in the exercise of engineering judgment. In the experiments before the society he had kept the shape of the blade constant, choosing the elliptical contour, though there was no special virtue in the ellipse. No attempt had been made to put the formula in ready shape for design, as it seemed inadvisable at this time. If able to complete the investigation he hoped to present the data by means of formulæ. As to how accurately that would represent the conditions in large propellers depended upon how accurately model experiments might represent the actual performances of large boats. There was a large amount of model data in Froude's paper which related to the determination of the values of the coefficients h and k in the paper under discussion. It was possible by reasoning and the use of existing data to obtain approximate values of the regarding both amount and distribution. It would be unfair to the original experiments of Mr. Froude, however, or to any similar experiments, to force the data very far away from the conditions under which they were taken. It was possible, however, to depart slightly from the elliptical form of blade, and from the area, and reproduce satisfactorily the conditions of Froude's experiments. He referred to two such formulæ; one a formula by Robert Caird in the proceedings of the Institute of Engineers and Shipbuilders of Scotland for 1895, and the other presented to the society last year by Professor McDermott. The first did not take account of the variations of a and i. That of Professor McDermott took account of the variations of area—the factor a—but variations of shape were not considered.

Dr. Emery asked if the author intended to make experiments to obtain the thrust with propellers of different sizes.

Professor Durand replied that every additional variable introduced meant several years' work. Personally he believed that this information was less needed than some other. It was possible to step with more confidence from the results of a propeller 1 ft. dia. to one 2 ft. dia., or from one 2 ft. dia. to one 5 ft. dia., than to step from a shape of one kind to a shape of another kind, or from an area of one kind to an area of another kind.

F. L. Du Bosque related an experience with shape in a ferryboat. Wheels of the Delamater type failed to give the required speed by a mile and a half. These were changed for wheels of the Thornycroft type, with blades bent far aft and with the greatest area near the center of blade. With these of seven inches less diameter, and about 38 per cent surface, a mile and a half more speed was obtained with a slightly increased horse power.

Professor Durand: "All my study of the matter both practical and theoretical leads me to place the highest importance on shape of blade, and from such data as I can obtain and such theoretical indications as we are able to arrive at, it is evident that the performance of a propeller will depend in high degree on the shape of the blade. The snape has here been kept constant simply in order to vary the area alone." He further expressed appreciation of the dependence of performance upon diameter, but insisted that where all other characteristics remained unchanged the step from one diameter to another could be made with more readiness than other changes, by the proportionality of the square of the diameter as expressed in the formula of the paper: $U = d^2 (pn)^a (a\ i\ h\ k)$.

Friday Morning, November 12.

Many members who had not been present on the first day were in the hall when Vice President William H. Webb took the chair at 10:40 o'clock in the morning. There were several absentees, however, so that the attendance was about the same as at the opening session. Mr. Webb called Colonel Edwin A. Stevens to the chair in the absence of John C. Kafer and the reading of papers was resumed.

NOTES ON THE NEW BATTLESHIPS.

"Some Notes on the Speed Trials and Experience in Commission of Our New Battleships," was the title of the paper by Chief Constructor Philip Hichborn, U. S. N., which in his absence was read by Assistant Constructor Frank B. Zahm, U. S. N. This is a brief statement of the behavior of the battleships Indiana, Massachusetts, Oregon, and Iowa, which, the author explains, should be regarded as "notes" in the absence of full data with which to prepare an exhaustive paper. The trials, however, have been sufficient to demonstrate the compliance of the vessels with contract requirements and their value as vessels of war. To the paper is appended an interesting table of estimated and actual weights of the battleship Iowa, which show that the net finished weight of the ship, with her designed coal, at normal displacement, was within 20 tons of the original estimate—the total finished weight being 11,127 1-2 tons, and the original estimate 11,108 tons. Owing to changes made during construction an exact comparison of some of the details of estimated and finished weights is not possible. The record of finished weights shows a total of 67 tons greater than that corresponding to the actual displacement of the ship. This, the author explains, is accounted for by small scrap, by trimming of wood

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work, loss of paint, and drying out of water contained in cement.

William H. Webb said he had experience in building large vessels and none was fitted with bilge keels. Half a dozen bilge keels would not prevent a vessel rolling unless they were large enough to seriously interfere with the speed of the vessel. He believed they were of little, if any, value, for if the model was not right no number of bilge keels would make it right.

Naval Constructor Joseph H. Linnard, U. S. N., said one point specially noted in the paper was the inadequacy of the trials. Ships were so badly needed when ready for commission that sufficient time could not be allowed for exhaustive experiments. The society should endeavor to impress upon the authorities the advisability of making exhaustive trials to determine the nautical and military qualities of each type. The wave profiles of the Indiana and Massachusetts, at speeds of about 13.75 knots, which accompanied the paper, showed a considerably greater wave disturbance for the Massachusetts than for the Indiana. The probable reason for this difference was the impracticability of obtaining accurate measurements of speed during the runs up the coast when the profiles were taken. Probably the speed of the Massachusetts was appreciably greater than the Indiana when the respective observations were made. As the ships were very bluff ships with full model, and not designed for high speed, the wave disturbance increased very rapidly with a small change of speed. The tendency in modern warship design was toward increased speed, and the speaker quoted M. Normand, who believed that, with the exception of fleet scouts and seagoing torpedo-boats, too much had been sacrificed for speed. The United States battleships had been criticised because they had not the speed of battleships of other nations, but the responsible designers seemed to be satisfied, as no material increase of speed was contemplated in the latest designs. In future, battleships would not likely be fitted with unbalanced turrets. The experience with the Indiana and Massachusetts showed that the position of the center of gravity outside of the center of rotation caused many inconveniences, not only in a seaway, but in the design of turning gear and other features. The balanced turret of the Iowa had proven eminently satisfactory. While it was true that it was necessary to overhang the rear end beyond the barbette, which had been objected to on account of the danger from shell explosion under the overhanging part, it should be remembered that this part was turned away from the enemy in action. The turret guns could be loaded in any position. As to bilge keels referred to by Mr. Webb, when fitted on the Massachusetts they had an obvious effect, and the British had had similar experiences. Bilge keels were, of course, a great annoyance, but on the five battleships now under construction a new design was being fitted. This consisted of a combination of docking keel and of bilge keel. In the center parts of the ship a wooded keel was fitted extending down to the level of the outer plate of the main keel, and placed at a sufficient distance from the center line as to support part of the weight of the ship when in dock. As the docking keels would be entirely too deep at the ends, there were placed at the ends, on each side, fins of the usual style of construction of bilge keels. These fins did not extend beyond the line of the midship section, so they would not be in the way in entering dock. While not as extensive as ordinary bilge keels, it was believed they would be effective, as experiments carried out recently in England showed unexpected value was obtained with shallow bilge keels. As superintending constructor of the Iowa it was a source of great satisfaction to the speaker that the designed weights so closely approximated to the actual. During the building there had been unanticipated increase of weights. After the battle of the Yalu river metal was largely substituted for wood, and all wood was ordered fire proofed, which perceptibly increased its weight.

Naval Constructor Francis T. Bowles, U. S. N., said the paper was practically an invitation to criticism of the battleships, and the absence of criticism from the officers who had had experience in them at sea he judged to be a matter of congratulation.

Lieutenant William P. White, U. S. N., agreed that the paper was a bid for criticism from the standpoint of the officer who goes to sea. They fully realized the limitations which the designers had been under in regard to draught and other dimensions, and that a compromise was necessary. Although they did not criticize the lack of speed in the battleships he was not ready to acknowledge that the speed arrived at—16 knots—was sufficient if more could be got. Unfortunately there were too many sacrifices in other directions, and if more speed was to be sought it would be at the expense of protection and weight of armament. Too many sacrifices had already been made and too small a limit in coal carrying capacity. Given opposing fleets, equal in every other respect, the faster had a decided advantage.

Naval Constructor John G. Tawresey, U. S. N., believed the comparison between designed weights and the displacement of the vessels a matter for congratulation. It was a common case to find the required weights, upon completion of the vessel, very much under the displacement. At first sight the reader would be at a loss to account for the excess of 67 tons. This was actually "small scrap," as all items of scrap of appreciable weight were weighed and deducted. In determining the displacement of the ships the actual density of the water in which they floated at the time the draught was taken was allowed for.

Alexander J. Maclean inquired if the "estimated weight calculated" was obtained from a known war vessel or from the drawings, and whether the center of gravity was in accordance with the designs.

Naval Constructor Joseph H. Linnard, U. S. N., in reply, said the "estimated weight calculated" was obtained by the usual process: as far as possible from the drawings, and otherwise it was estimated by comparison with other ships. The metacentric height of th Iowa came out within four one-hundreths of a foot. The designed height under conditions of normal draught and with certain coal on board was 4.27 ft., and the actual metacentric height, as determined under the same conditions, was 4.23 ft. As to the speed question he cited the results of a series of games at the Naval War College. In these a fleet of 12 vessels of 12 knots speed opposed a fleet of 11 vessels of 14 knots speed and defeated it badly. It was thus demonstrated that in a fleet action the value of two knots extra speed in a fleet, obtained under actual designing conditions, with a consequent decrease in the other effective qualities of a vessel, was not worth one ship in twelve.

Lieutenant White, U. S. N., in reply, said in the War College games one side had one move by which to know exactly what the ships of the opponent would do, and under such circumstances the advantages of speed were not nearly as great as in battle, when neither side knew how the other would maneuver.

Assistant Constructor Frank B. Zahm, U. S. N., said it would be a matter of much regret to the Chief Constructor that seagoing officers were not present

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to discuss the paper, especially as so many ships were now at the New York Navy Yard.

Colonel E. A. Stevens, from the chair, announced that the paper on the "Performance of Scotch Boilers and their Durability under Forced Draught," by Edwin S. Cramp, had not been handed in. The next paper on the list was on the "Use of Water Ballast for Colliers in the Pacific Coast Trade," by William P. Frear.

USE OF WATER BALLAST.

As the author was not present the paper was read by Mr. King. It deals with several types of vessels used in coal carrying between the Puget Sound district and southern ports, the return trips of these vessels usually being made without cargo and with water ballast. During eight months of the year the return trips are made against strong northwest winds and head seas. The paper deals with particular vessels, including the spar deck, partial awning deck, whaleback and Doxford turret types. Various structural damages sustained by the ships while sailing light, from racing, pounding, and rolling, are narrated by the author, who is of opinion that there should not be less water ballast than one-quarter the dead weight capacity of the ship, and if she is unusually full or club footed forward one-third would be the more desirable proportion. Diagrams accompany the paper showing ballast tanks located on the main deck as well as in the bottom.

The discussion on this paper was brief. Lieutenant W. P. White, U. S. N., favored the French naval practice of putting a long protruding snout to seagoing vessels. He told of an experience while on the Olympia, steaming against a very strong southwest monsoon. A French cruiser of the Jean Bart type, with high freeboard forward, was able to maintain a 12 knot speed, while the British cruiser Crescent had to slow down, and the Olympia also. The latter had been running at 21 knot speed, but took a sea over the bow, which very nearly crushed in the forecastle, bending stanchions, and distorting beams.

Attention was now given to a supplementary list of names of persons which the Council recommended for membership. This list, as read by Secretary Bowles, included:

Members—William B. Beckley, Charles B. Edwards, Louis W. Walker, and Andrew Wood.

Associates—Harrison B. Moore, Henry G. Barbey, Joseph Barre, William Boyd, Hazen J. Burton, Oswald Sanderson, Joseph F. Tams, Charles E. Wheeler, T. C. Zerega, Ridgely Hunt, U. S. N. (Ret.) and Henry M. McLaud, Halifax, Nova Scotia.

The recommendation of the Council was carried unanimously.

Friday Afternoon, November 12.

At 2 o'clock Member of the Council John C. Kafer again called the members to order from the chair, and announced that in the absence of Professor George R. McDermott, the paper entitled "Estimated Weights of Machinery" would be read by Professor Durand.

ESTIMATED WEIGHTS OF MACHINERY.

The formulæ presented by the author represents the work of many years of business life, during which he had gathered recorded detail weights of machinery of more than 300 vessels, embracing all types to be found in both warship and mercantile fields of service. The formulæ is classified under these leading divisions: (1) Engine room weights. (2) Boiler room weights. (3) Shafting weights. (4) Propeller weights. Further subdivisions include naval and mercantile vessels and both paddle and screw machinery. Tables accompany the paper giving the leading particulars of machinery of a selected number of typical vessels, both war and mercantile.

By way of comment, Chairman Kafer, after the paper was read, said he would take exception to some of the formulæ given, naming that which applied to the weights of engines. In this D was incorporated as a factor, D representing the sum of the squares of the diameter of each cylinder directly connected to cranks. Then the author extracted the square root of that, which brought it down practically as a factor to the diameter of the cylinder, so that a cylinder of double the diameter would mean double the weight, whereas the area of cylinder heads and the pistons would vary as the square of the diameter if they were the same thickness, and it was a well known fact that where the distance between the support was greater, the thickness and strength of the various parts would of necessity have to be greater. So, for engines of the same stroke, the area, and consequently the weight, must vary as the square of the diameter. From his own experience, and from a number of engines he had tabulated and arranged, and from many calculations he had made as to the weight of engines, he always used the square of the diameter of the cylinder, making the factor the mean of the diameters of the three cylinders of a triple expansion engine, or the mean of the diameters of the two cylinders of a compound engine. In his experience, the weight of engines varied very nearly as the square root of the length of stroke, because an engine is built to withstand pressure, the stress varying as the square of the diameter of the cylinder, and the area of piston rod, the connecting rod, the crank and crank shaft varying proportionally. The walls of the larger cylinder, with the same thickness, would vary directly as the diameter, but it was a general practice to make the walls of the large cylinder very much thicker than the smaller cylinders, not so much for strength as to preserve rigidity. Thumb rules, the result of experience, were used in building engines, and it was largely a question of judgment. No one could tell whether a little water might not come over with the steam and create havoc. In torpedo boat engine design the cylinder heads were made so light that they would spring, and yet the designer, while saving this small amount of weight, would invite a number of persons on board during a trial trip whose total weight would approximate to the weight of the entire engines. It seemed foolish to reduce the weight of any particular part of the engine where there was likely to be an accident due to improper condition of the steam. With reference to Scotch boilers it was unnecessary in the ordinary type of boiler to go into much detail with regard to approximate weight. All boilers varied as the squares of their diameters, in the main, because the thickness and surface varied directly as the diameter. The heads vary as the squares of the diameter, because they may be, approximately, of the same thickness in a small boiler as in a large boiler. The number of tubes and the interior of the boiler—the socket bolts and other details—also vary as the square of the diameter, and multiplying by the length and by the steam pressure, and using with this formula a factor of about .22 in some cases, the approximate weight could be found.

Colonel Edwin A. Stevens said, in designing machinery, after the power was determined the next deduction was the number of square feet of heating surface. It was easy enough to select out of published trials the units generally given. The number of square feet per indicated horse power was an easily accessible quantity. The easiest way to get

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weight was on the basis of square feet of heating surface. He suggested that Professor McDermott add to his paper formulæ applicable to water tube boilers.

Mr. Newman believed that in working out weights the most satisfactory method was to arrange the engines in types. Experience showed that in the engines for battleships 12 to 13, or even as high as 16 indicated horse power could be got on a ton of weight, of engines, boilers, and all. In H. M. S. Nile 16 had been secured. In later vessels heavier boilers had been used. In British crusiers of the Blenheim class 12.8 was the figure attained, and in the torpedo catchers Sharpshooter and Salamander 20 to 23 indicated horse power. In the machinery of an ordinary tramp steamer 6 to 7 indicated horse power per ton of weight was considered good. High speed passenger vessels more closely approximated to naval conditions. He advocated the use of cast steel in place of cast iron to keep down weight.

Mr. Roberts related his experience with heating surface. Years ago in several horizontal tubular boilers, set in masonry, the tube ends became thin. He cut off one course of shell plates, cut off the bad tube ends and set back the head, making the boilers 12 ft. long instead of 16 ft. The result was more steam, greater economy. Judging from this experience it would be difficult to estimate the weights of boilers, taking H. P. into consideration, by the heating surface.

Mr. Cowles suggested: "If you increase the efficiency of the boiler by cutting off 4 ft., you might cut off 8 ft. and increase it still further?"

Mr. Roberts, in response: "Supplement that by increasing the length of the boiler to double what it was originally, thus doubling its capacity according to the general method of valuing boilers by the heating surface irrespective of grates."

A. J. Maclean, in his experience in British shipyards, had found that engine builders differed very considerably in estimated weights, and as to the center of gravity, that was never given correctly. Each engineer had his own way of putting in different material, and one hard and fast formula was not satisfactory for all kinds of machinery.

Mr. King called attention to the lack of data about marine beam engines. The author had classified paddle engines into oscillating and inclined engines and had entirely ignored the beam engine. The speaker had felt the need of such data in practice. In his preliminary work in design he had always calculated engine weights on cylinder cubic contents, and boiler weights on cubic contents also. In a multiple cylinder engine it was not necessary to consider the capacity of all the cylinders, a more ready method being to take the capacity of the low pressure cylinder and have a separate co-efficient determined for a triple, compound, and a single engine, of standard types. The formulæ furnished by Professor McDermott would have to be used with discretion, as a source of error would be that the data given was largely determined from big engines. He did not suppose that, for example, the figures given would be applicable to a tug boat engine without a considerable allowance. In small engines castings were considerably thicker than they would be if proportioned from the larger engines. The foundrymen insisted on this. The formulæ also took into account the engine room weights outside of the main engines. Actually the weight of floor plates and other paraphernalia about the engines would be much greater in the case of the smaller engine. As to boiler formula he did not think the author took account of the great range of pressures in use. The figures were drawn simply for triple expansion engines, with a pressure of 160 to 165 pounds, but the author had taken into account the heating surface and size of furnace. These the speaker regarded as immaterial in making up weights. Steam pressure was more material, and it was convenient, and within practical limits, in the case of the Scotch boiler, to take the cylindrical contents and have a coefficient for the several pressures—100 to 165 pounds for triple expansion, 110 pounds for compound, and 60 pounds for single engines.

Stevenson Taylor, speaking to the references to the beam engine, said it needed no defense. From the standpoint of the engine repairer this engine was not as good as many others. His firm had just made a contract for a beam engine for parties who had purchased a beam engine of them about 16 years ago. This engine the owner considered "first class," as in all the time it had been running the cost of repairs did not amount to $500. His experience with weights had been peculiar, in that the firm never built two boats alike, unless two were built at the same time for one purchaser. He had, moreover, much available data and with the aid of a good memory could readily make weight approximations without the aid of any special table or formula.

Professor Durand replied briefly, in the absence of the author, that the paper was the result of many years investigation, and the forms used had only been adopted after long consultation, in which the speaker had participated. He suggested to those who preferred to make estimates on the basis of so much weight per indicated horse power, or so much heating surface, or other proportion, that they would find all necessary data in the tables attached to the paper.

PNEUMATIC STEERING GEAR.

"Pneumatic Steering Gear as Applied to the U. S. Monitor Terror," by H. A. Spiller, was read, in his absence, by Secretary Bowles. This describes an installation of a direct steering gear in which two athwartship cylinders are used with pistons attached to the same rod, which carries at mid-length a slotted head fitted with brasses permitting the sliding of the tiller as its angularity changes. The cylinders are situated to starboard and port. A pressure of 125 pounds per square in. is available in the steering cylinders, and this is supplied when under way by one of the main air-compressing engines of the ship, which is run at 4 revolutions per minute. Steering is effected from the chart house or the forward turret by the use of the ordinary power wheel, connected by wire ropes with a pneumatic valve in the tiller room, or by a handle for controlling an electric motor which operates the pneumatic valve. Telltales are also fitted to show the helm angle. The gear has been in regular use on the Monitor since April, 1896.

John G. Williamson criticized the operation of the rudder direct without any intermediate gear. The movement direct from piston to tiller made a very rank movement and consequently the quartermaster would have to have much experience with the apparatus to make it steer as finely as with the steam steering engine. The common proportion of movement of piston in the ordinary steering engine to that of the end of the tiller or quadrant was about 16 to 1, so it did not require the same care to steer finely as with the direct movement. The latter had been used before both for hydraulic and pneumatic steering, but the objection to the rank movement had caused such gears to be replaced by steam engines. He had noted that the least time from hard over to hard over in the Terror was 4 seconds. This was a very dangerous speed, and greatly in excess of what it should be for the safety of the rudder and connections. The common practice in river and coasting steamers was

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from 10 to 20 seconds, according to size and speed of boat. The specifications for naval vessels called for 20 seconds from hard over to hard over and even this speed was nearly double that of the transatlantic liners Campania, Lucania, St. Louis, and St. Paul. In these the time ranged from 35 to 40 seconds. On the SS. St. Louis the steering engine was originally proportioned for the speed of 20 seconds, but after months of service this was altered to the slower speed of 35 seconds. The theory that the rudder should be made to go hard over as soon as possible to steer quickly was not correct in practice, as it not only retarded speed, but was dangerous to rudder and connections. If the rudder could be brought hard over instantly, the vessel would require time to overcome the inertia before the stern would move, and then the movement would be gradual; so that by giving a gradually increasing pressure on the rudder it would give as good a resultant and much less danger.

Lieutenant William P. White, U. S. N., spoke of the advantage of compressed air in place of steam on account of the heat from steam pipes, which made hot houses of certain compartments and was very trying on the men, especially in the tropics. Compressed air could also be used for handling turrets and ammunition, an advantage steam did not possess.

Naval Constructor Joseph H. Linnard, U. S. N., said the main objection to steam steering gear seemed to be on account of heat produced and not because it was not thoroughly satisfactory in operation. This objection could be removed by putting the air compressing engine in the engine room and piping air instead of steam to the steering engine. He had no doubt of the success of the pneumatic gear on the Terror, but this arrangement could not be adopted on some of the modern fine steamers as it occupied too much room. The ordinary steam gear was very durable and worked effectively even when receiving almost no care, for months at a time.

Mr. Newman considered the apparatus excellent, but had found that its cost was nearly twice as much as the steam steerer. He quoted Mr. Linnard as advocating the placing of a compressing plant in the engine room.

Naval Constructor Linnard, U. S. N., interrupted to say he had expressed no opinion as to the "advisability" of doing so.

Lieutenant William P. White, U. S. N., got the floor again to speak about the rapidity of action which had been criticized by Mr. Williamson. "The Terror being a flat bottomed monitor, having very little hold in the water, is very difficult to steer," he said, "and it is necessary to have a very quick acting rudder in order to go from one helm to the other. The helm is not shifted in any such time as would be indicated by the experiments, that is only the speed which can be obtained. * * * * We know that it takes some appreciable time for a ship to start after the helm has been put over. Sometimes the helmsman puts over his wheel and the ship does not seem to start. He looks at the compass and it may be a bit sluggish and he takes another turn, and the first thing he knows, if he is not an experienced helmsman, the ship is going off at almost a tangent from its course. Then we want to right the helm as soon as possible. Speed of movement to get the helm back to midship position is very desirable. You cannot get it back too quickly, you can put it over too quickly."

Colonel Edwin A. Stevens, speaking of vessels in inland waters, especially ferryboats, said the objection to the direct application of the piston to the tiller was the uncertainty as to where the helm would stop. In harbor work it was absolutely necessary to know where the helm would stop, and in all experiments he had known, except in some small craft, the direct action in the quadrant or tiller had been abandoned in favor of some other method by which a short stroke engine could be used. The old fashioned way of heaving over the wheel by hand had to be reproduced as closely as possible. The prime necessities in inland waters were: certainty of action and reliability of gear. Speed while desirable and even essential was secondary to certainty, and he did not know of any gear in which certainty had not been attained which had met with any success at all.

F. L. Du Bosque desired to emphasize Colonel Stevens' remarks about the necessity for "certainty" in ferryboats. The present steering engine, however, was very expensive on steam consumption. The power of the engine was made to greatly exceed the power required for turning the rudder so as to make it sure, and the gear used for applying the reciprocating engine was very wasteful. It was generally recognized that a direct application to the tiller was desired—the ability to steer quickly. Owing to condensation this was not possible with steam as a medium, for the tiller could not be held in the position it was placed in. With air this was possible as there was no condensation. Another present source of waste was that the steam engine was sufficiently powerful to pull the tiller, say, in the range of 32 to 35 degrees. It possibly took only one-tenth of this power to pull the tiller from 1 to 10 degrees, and the power was not applied proportionally to the amount used.

William B. Cowles believed that the question of additional expense attending the installation of an air compressor need not apply to a warship. A battleship was full of auxiliaries, and land practice might be copied in the working of these, to the extent of placing a plant in the engine room which would supply power to all points. By constructing a suitable reciprocating engine to use air it would then be possible to continue the present type of steering gear.

Chairman John C. Kafer, in further discussion of the paper, said that if air was used instead of steam in the ordinary steering engine, as had been mentioned, it would simply add another machine to accomplish the same purpose. "If you wish to pay twice the price for the same object, you are perfectly at liberty to do so," he remarked. "As to heat, steam pipes can readily be covered so as not to radiate much heat, and the steam steering engines now in use are perfectly satisfactory. With a very small motion of the piston of an ordinary steering engine the vessel can be kept straight very easily. In sound steamers a man can move the wheel with his finger and the helm follows the finger and stops with it—does not go any farther. With a pneumatic gear attached directly to the tiller, whenever you allow the air to exhaust you must reduce the pressure, and that air is gone for good. The excess of pressure on the other side will force the piston over until the valve opens again and admits air on the opposite side, and thus it requires a great deal more air to do the same work, than would be equivalent to the amount of steam used in an ordinary steering engine. The question of cost is really immaterial, because the absolute cost of running the steam steering engine is very small as compared with the amount of steam used in the main engines of the ship, and the great advantage desired is certainty of action. As to elasticity, the ordinary ropes that are used to pull the helm over answer the purpose and are positive in their action."

NAVY YARD EXPENSES.

"Navy Yard Expenses," by Naval Constructor William J. Baxter, U. S. N., was next read, at the request of the Chair, by Mr. Tawresey. The author opens by stating there is no fixed standard by which to judge the expenses of navy yards, because the conditions are so dissimilar to those existing elsewhere. The output of navy yards is generally believed to be very costly, but a consideration of facts will show that the total cost of navy yard work has been less than supposed, and even this difference has been due

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to conditions now disappearing and which may vanish in the future. Present differences are mainly owing to higher prices of labor and material, lack of labor saving appliances, and, at times, to the exigencies of the naval service. While advocating the "carrying on of new construction in the navy yards at all times," the author expressly disclaims any suggestion "that warships should only be built in the navy yards."

Naval Constructor Francis T. Bowles, U. S. N., opened the discussion by stating his belief that war vessels could be built in the navy yards cheaper than elsewhere, but not under present conditions. Reorganization would be necessary to eliminate the system which made no person responsible and permitted no person to come in contact with those whom he had to deal with. In his experience of navy yard work he found that in the purchase of material, for example, he was not permitted to deal direct with the person who supplied the material.

Assistant Constructor Frank B. Zahn, U. S. N., believed there was no reason why the obstructions due to inefficient plants and insufficient funds should not be corrected, but administrative difficulties in the purchase of materials and like matters could not be easily changed, owing to the military status of the navy yard.

Lieutenant William P. White, U. S. N., spoke of the necessity for speedy repairs to vessels sent to the Navy Yards. There should be no difficulty in the military administration of the yards to prevent this. The officer in charge of a Navy Yard had not usually a sufficiently large staff to supervise the work in hand. Workmen who knew that a repair job would only last a few days took pains to nurse it, and this would not be possible under closer supervision. In order to retain an efficient force at the navy yard it was necessary to carry on sufficient work to make the work economical, and first-class workmen could not be hired for a few days and then laid off indefinitely. When a ship went to the yard to be overhauled the captain of the ship should be the judge of what work was absolutely necessary, and the carrying out of this work should be left in the hands of the navy yard officers.

Mr. Newman disagreed with the previous speaker. The captain of a war vessel was not fitted by practical or theoretical training to decide what repairs should be made. "I do not see how you can expect the captain of a ship to decide as to whether a ship requires repairs no more than you can expect a shoemaker to prescribe to you for the body," he declared.

E. Platt Stratton compared the navy yard to the frontiersman's pistol: "You do not want it often, but when you do, you want it terrible." In times of peace navy yards were not of much use, but in war time they would be needed badly.

Naval Constructor John A. Tawresey, U. S. N., said there was an impression that navy yard work cost from four to five times as much as work in private yards, which was not true. Frequently in doing work in a navy yard the question of what account it would be charged to was raised. So long as new work was going on money was available, and often when there was little money in the regular appropriation for the particular work in hand, charges were made against new work. He believed supervision of work in navy yards was as effectively carried out as in private yards. Repairs were costly in navy yards, as when working on a ship in commission the cost was increased by the presence and interference of persons on the ship, as compared with what it would be if the ship were out of commission. The system of placing inspectors in charge to build new ships economically had been tried and found to have an opposite effect.

Chairman John C. Kafer remarked that the author had proved that work in a navy yard cost a great deal more than work in a private establishment, and the speaker's own experience enabled him to concur in this. Work in a private yard must pay a profit while in a navy yard this was not necessary. He agreed with Mr. Newman that the captain of a ship was not the proper person to decide upon the extent of repairs. In a merchant ship this was decided by the representative of the owners, the underwriters, or some one in charge. If there was direct damage to a warship the captain could report what the damage was and recommend that repairs be made at a certain yard. It should then be the duty of the Naval Constructor at that yard to determine how, and to what extent, the repairs would be made.

Naval Constructor Francis T. Bowles did not want it to go forth that the navy yards had to be kept up at enormous expense, for the simple reason that they would be needed in time of war. There would not be much difficulty in organizing the navy yard so that work could be done more cheaply there than elsewhere.

Chairman John C. Kafer believed such results would never be accomplished until it was possible for the Naval Constructor to give orders by telephone, throughout the country if necessary, for whatever material was needed and to do work without interference and with full authority in the yard.

E. Platt Stratton moved a vote of thanks to the American Society of Mechanical Engineers for the use of the society rooms, and this was carried heartily. Then Chairman Kafer declared the meeting stood adjourned without date.

Steamer Ulster Goes Ashore in Hudson River.

On Thursday, November 11, at midnight, the Hudson River steamer Ulster, of the Saugerties and New York Steamboat Line, while on her down trip, ran ashore at Storm King, about one mile below Cornwall.

Her bow ran within five feet of the West Shore Railroad tracks, which are twenty or twenty-five feet from the water's edge. The passengers immediately went ashore and most of the freight was also taken ashore before 7 o'clock in the morning, when the tide came in, and partly filled the hull with water. She then slid back a few feet and sank, leaving the bow sticking on the rocks, exposing ten feet of the keel, while the stern was entirely submerged. A wrecking concern was instructed to take charge of the steamer, and before they could arrive with their wreckers, the Ulster had loosened herself and floated to West Point, where she collided with a sand sloop and again sank. Subsequently she was raised, pumped out and towed to Marvel's shipyard at Newburg, where she will remain this winter for repairs. Before the Ulster leaves this yard she will be practically a new boat, as the hull is to be thoroughly overhauled, and she is to have new joiner work throughout.

The Ulster is a sidewheel steamer 205 ft. long, 30 ft. beam, and 8 ft. draft. She is fitted with the regular type of condensing beam engine with 42 in. cylinder and 8 ft. stroke. She had one return tube boiler 19 ft. 8 in. long and 126 in. dia., fitted with four flues and 108 4 in. tubes, which are 12 ft. long. A boiler pressure of 45 lbs. per sq. in. is carried.

The hull is of wood and was built in 1892 at the Burtis shipyard, in South Brooklyn. The damage below the water line is as yet unknown, but it is known that the hull stood the strain remarkably well, as the boat, at present, only leaks slightly.

The engine and boiler were built in 1892 by McCurdy & Warden, in New York city, and do not appear to have been much damaged. The stern was very badly damaged, and the stateroom hall and ladies' cabin were completely destroyed. The damage is estimated at between $10,000 and $15,000.

Ezra Whittaker, the pilot, forwarded the following report to the local inspectors of steam vessels for the district of New York:

"I left Saugerties with the steamboat Ulster at 6 P. M. on Thursday, November 11, on our regular trip

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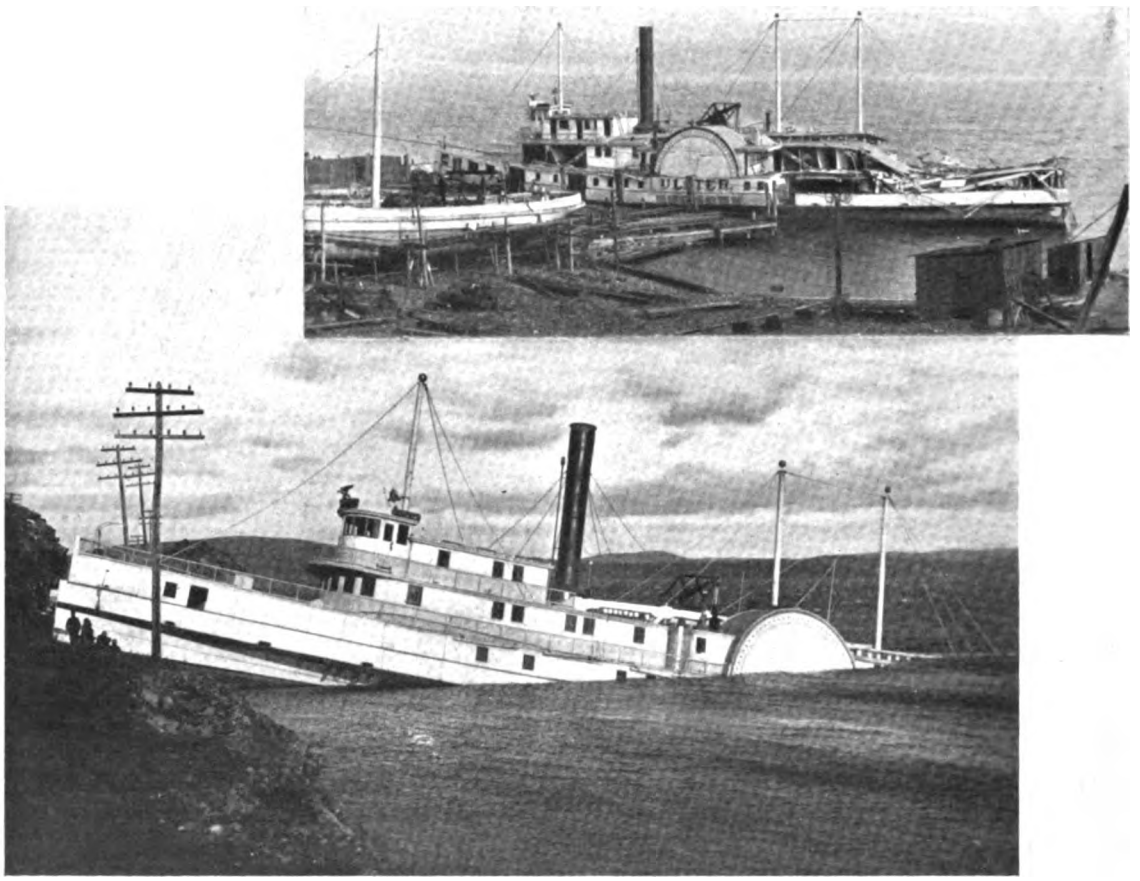
to New York, with freight and passengers. We made the usual landings and proceeded down the river. Charles Tiffany, wheelsman, was with me in the pilot house. A few minutes before midnight, when nearing Storm King, at the entrance to the Highlands, Tiffany brought me a sandwich, and I sat down in a chair and ate it, while he took the wheel. He then said to me: 'Cap, take the wheel a minute.' I arose and took my position at the wheel, and he stepped out, leaving me alone. In a very short time, probably not more than two minutes, I was seized with violent cramps, so severe that I was unable to stand up, and sank back into my chair. As near as I am able to judge it was about two minutes before I was able to rise and look out, and at that moment the bow of the Ulster was about to strike the shore. It was too late to stop her or change her course, and she ran into the bank. Some time between the moment that I sank in my chair and the time the boat struck I was hit by the wheel in my back, breaking two of my ribs and cracking another."

We have pleasure in acknowledging the aid of Andrew Templeton, of Newburg, who took the very excellent photographs reproduced herewith.



VIEWS OF STEAMER ULSTER ASHORE IN HUDSON RIVER AND SUBSEQUENTLY AT YARD FOR REPAIRS.

A queer sucession of mishaps occurred to a 2,000 ton British tank steamer in the North Sea. While on a voyage from Philadelphia to Aarhuus with petroleum she went ashore in the Kattegat. The shock burst a tank and the oil poured into the stokehold and was ignited. The crew then abandoned the vessel and an explosion occurred shortly afterward, tearing a big hole in the side through which water came in and drowned out the fire.

EDUCATIONAL.

ELECTRICITY ON BOARD SHIP, PRINCIPLES AND PRACTICE.—V.

BY WM. BAXTER, JR.

The general principles of the electro-magnetic action have been explained sufficiently in the preceding articles to enable us to proceed at this juncture to consider the manner in which these principles are applied in the actual construction of electric machinery.

The simplest form of electric motor or generator is that known as the two-pole type. Fig. 26, shows the appearance of one of the numerous machines of this class now upon the market. A diagramatic representation of this particular type of two-pole machine is shown in Fig. 27. The base, together with the uprights, on either side of the shaft, constitute the field magnet, commonly called the field. The extensions of the base in the direction of the shaft are not strictly a part of the field, as they play no part in the magnetic action, their only function being to support the shaft. The portion of the base between the uprights is generally made a solid, or nearly so, so as to afford a path of sufficient cross section for the magnetism, but the extensions that support the bearings are cored out leaving only as much metal as may be necessary to give the requisite mechanical strength. In Fig. 26, the wire through which the current that magnetises the field is passed is wound

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upon the uprights, as can be clearly seen from the cut: it is formed in two coils which are called magetising coils. The portion of the base which connects the lower ends of the uprights is called the yoke, the portion of the uprights within the coil is called the core, and the portions above that, between which the shaft revolves, are called the poles. The cylinder upon the shaft, between the poles, is the armature; it

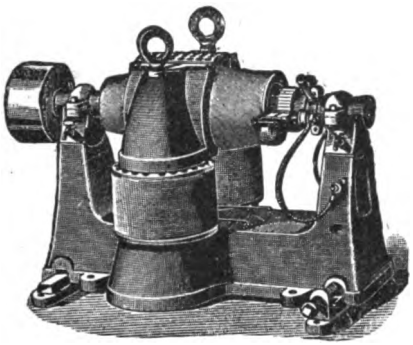

FIG. 26.

is wound with wire, and this is caused to cut through the lines of force of the magnetic field, developed between the poles, by the rotation of the shaft. The small cylinder at the end of the armature, upon which stationary pieces are seen to rest, is the commutator, the office of which, as already explained, is to rectify the current generated in the armature. The parts that rest upon the commutator are the brushes through which the current is conducted to the external circuit.

Machines of the two-pole type are made in a great variety of forms, but they all operate upon the same general principles. In the early days of electrical development, nearly all machines were of this class, and as the theory of the subject was not very well understood, it was believed, by many, that modifications in the shape might lead to extraordinary results. Whether they did or not they gave inventors an opportunity to point out the difference between

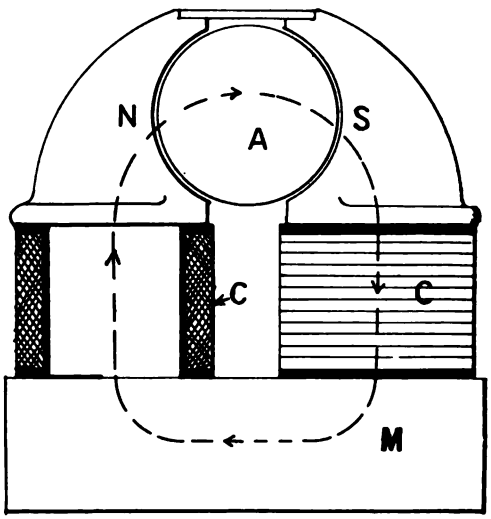

FIG. 27.

their machine and all others, and to claim a great superiority as a consequence of this difference. It would be a difficult, and in fact useless, task to present a full description of all the two-pole machines that have been brought to public notice, the great majority of which have no distinguishing features except their fantastic appearance; but as the vast number may be divided into a few distinctive types it will be well to illustrate the most prominent of these.

Fig. 27, as already stated, is the type to which Fig.

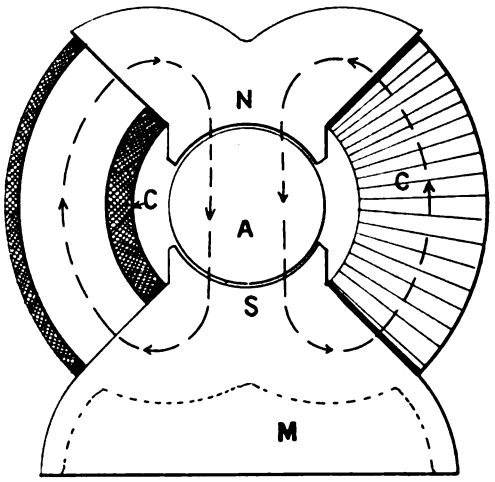

FIG. 28.

26 belongs; Figs. 28, 29 and 30, are three other types. Each of these can be modified in several ways. Thus Fig. 27, can be inverted so that the poles will be at the bottom and the yoke at the top; it can also be laid on its side, the outline of the various parts in these different positons can be changed to an almost unlimited extent, thus producing any number of machines having but a slight resemblance, but all substantially the same. The difference between the upright and the inverted modification would be greater than between any other, although the difference might not be noticed by those not familiar with the principles of electro-magnetic action. As in the inverted form the poles come directly on top of the base, the machine will not act unless a brass block-

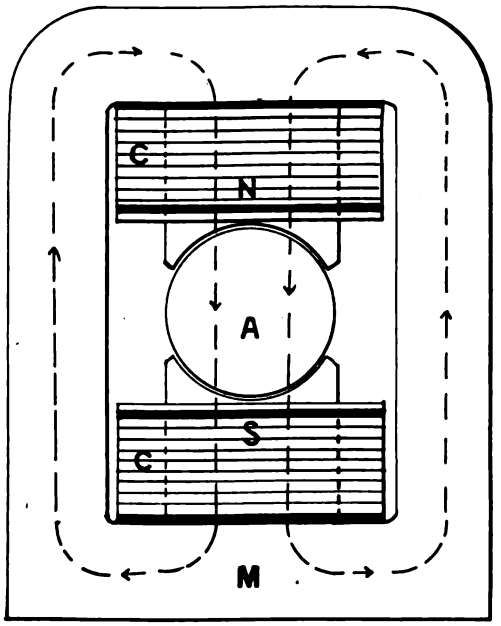

FIG. 29.

ing piece is interposed between the two. As the base is made of iron, if the poles rested directly upon it the result would be that the magnetic lines of force would pass from the ends of the pole to the base, and

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thus evade the armature. As the latter will not develope an electro-motive force, unless it rotates through lines of force no current would be generated. If, however, the poles are separated from the base, and the intervening space is filled in with a frame made of brass, the lines of force will nearly all pass through the armature, as brass, being a non-conductor will not allow the magnetism to pass through it with any more freedom, if as much, as would air. The Edison machine is the best known of the inverted modification of type Fig. 27 of two-pole machines.

The types shown in Figs. 28, 29 and 30, as can be seen, are very different from type Fig. 27. In the latter it will be noticed that the lines of force have only one path in which to circulate while in the other three figures, they have two. These paths are indicated by the broken line curves. So far as the magnetic circuits are concerned, the difference between these types is that Fig. 27 has a single magnetic circuit and the other three have a double magnetic circuit. Between Figs. 28, 29 and 30 there is still another difference. In Figs. 28 and 30 each magnetic circuit passes through a separate magnetising coil, but in Fig. 29, both circuits pass through the two coils, and, therefore, this type may also be regarded as belonging to the single circuit variety; for in that part of the machine in which the lines of force are developed, the two circuits emerge into one.

Whether the magnetism follows one or any number of paths after leaving the armature would make no difference if it were not for the fact that the magnetising force, that is, the amount of electric energy, and the length of wire required, is not the same with single and multiple circuits. The total magnetising effect of the electric current passing through a coil of wire is proportional to the area inclosed by the coil and the length of the magnetic circuit. If the length of the circuit remains the same, a given number of turns of wire in the coil traversed by a given current, will develop the same number of lines of force per square inch of cross section of the area within the coil, whether this area is large or small. To make this more clear, suppose the length of the magnetic circuit in Fig. 27, is the same as each one of those in Fig. 30, then to develop the same number of lines of force in each square inch of cross section of the core, in both machines would require the same number of turns of wire in the coils. That is each one of the coils in Fig. 30 would have as many turns as the two coils of Fig. 27 combined, for in this figure, both coils act upon the same circuit and, therefore, may be regarded as halves of one and the same coil. As the magnetising effect of the current is in proportion to the number of turns of wire wound around the magnetic circuit, it follows that the greater the number of circuits, the greater the current and wire required to develop the same magnetism. A coil ten inches in diameter will develop a total magnetism four times as great as a coil 5 in. dia., because a 10 in. circle is four times the area of a 5 in. one; but the circumference of the large circle is only twice as great as that of the small one, hence four times the magnetism is obtained with twice the electric energy, and double the length of wire.

Inasmuch as it makes no difference, so far as the amount of magnetising current is concerned, whether the magnetic circuits divide after leaving the coils or not, we may define single magnetic circuit machines as those in which all the lines of force that pass through the armature, also pass through each magnetising coil, and multiple circuit machines, as those in which only a part of the lines of force pass through each magnetising coil.

Although the single magnetic circuit machine can be magnetised with less current and less wire theoretically, practically the full advantage cannot in all cases be realized, owing to the fact that, as a rule, when two or more paths are provided for the lines of force these paths can be made shorter, and therefore there is a gain in this direction to compensate for the loss in the other. In the diagrams shown it can be seen that in Fig. 28, the length of the circuits can be made less than in Fig. 27, and this is also true of Fig. 30 although its circuits might also be longer than that in Fig. 27. The construction of Fig. 29, however, is such that the length of the magnetic circuits cannot

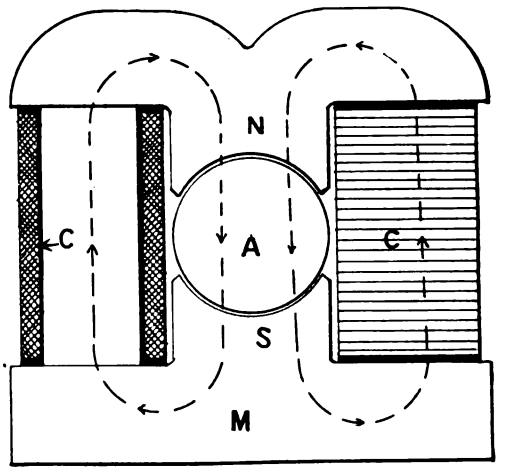

FIG. 30.

be made as small as in Fig. 27, unless the coils are brought so close to each other as to overlap on the armature, and this is somewhat objectionable owing to the fact that the machine cannot be put together unless the field magnet is split in the center so as to be lifted off the top. Thus it will be seen that a very large portion of the advantage of single magnetic circuit machines can be lost if the design is such as to greatly increase the length of the magnetic circuits. The difference in the effectiveness of the magnetising coils is not directly proportional to the actual difference in the length of the path in which the lines of force circulate, owing to the fact that the resistance of all parts of the circuit is not the same. If the entire circuit were iron then its length would be an accurate measure of the number of turns of wire required to develope the required magnetism, but as part is iron and part air the case is altered. The resistance that air interposed in the path of the magnetic force is about 400 or 500 times as great, per inch of length, as that of iron. Therefore in making a comparison of the length of any two or more circuits, the air portion of each should be multiplied say 500 times, and when this is done it will be found that the iron part is possibly but a fraction of the whole. For an example suppose the length of the iron in Fig. 27 is 40 in. from pole S around to pole N, in the direction of the arrow head and through the armature 10 in., which would make 50 in. in all. Now suppose the distance from the face of the poles to the iron core of the armature is 1-2 in., then the total air space will be 1 in., and if this has a resistance 500 times as great as iron, it will be equivalent to ten times the length of the iron part of the circuit. Under these conditions an increase or decrease of say 10 in. in the length of the iron part of the circuit would only amount to an actual change in the length of the circuit of ten in 550, or about 2 per cent. If the air space is 1-5 in. instead of 1 in., the total length of the circuit would be equivalent to about 150 in., and then a difference of 10 in. would amount to about 7 per cent.

A sum of $100,000 is said to have been expended by Harland & Wolff, the Belfast shipbuilders, in preparations for the construction of the new White Star liner, Oceanic. Of this sum not one cent represented any work or material for the vessel. Among the improvements is included the erection of a powerful cantilever crane for handling the material over the ship.

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